



LOW COST HOUSING IN

WEST AFRICA

(A HOUSING PROGRAM WITH A METHOD OF
LIGHT PREFABRICATED CONSTRUCTION FOR
A WEST AFRICAN CAPITAL, DAKAR)

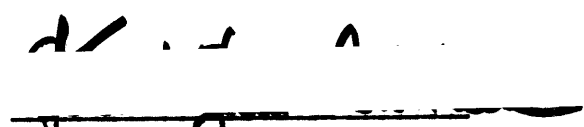
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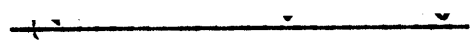
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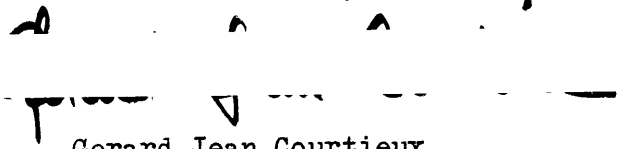
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June 19, 1967.

Dear Dean Anderson,

In partial fulfillment of the requirements for
the Degree of Master in Architecture, I hereby submit
this thesis entitled "Low Cost Housing in West Africa".

Respectfully,



Gerard Jean Courtieux

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Additional credit should be given to the following persons for their helpful advice during the course of this study :

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Mr. J. Turner

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ABSTRACT

The greatest difficulty in determining housing policy in the countries of West Africa, as well as in other underdeveloped countries, in general derives from the following points :

1. Until now, technology has been unable to reduce the construction cost of durable housing beneath a price of about 410,000 FCFA or US \$ 1,640 for a 40 m² unit at Dakar, including all costs.
2. The credit available to developers is such that low cost housing can only be rented to families whose income is greater than 20,000 FCFA or US \$ 80 a month, which represents from 10 to 40 percent of the total population in most underdeveloped countries.

This study will attempt to contribute to the solution of these two problems: first, from the point of view of technology with a system of industrialized prefabricated construction and a study of high density lot subdivision, and second, from the point of view of finance with suggestions for new methods of financing and construction.



1. INTRODUCTION TO SENEGAL

The housing project to be studied will be located at Dakar, capital of the Republic of Senegal. Senegal is approximately the size of France and is on the West African Coast.

1.1 NOTES ON SENEGAL

Senegal is a former French colony which gained independence in 1960. Her resources are essentially peanut by-products and phosphates.

Senegal is completely flat and lies between the desert zones of the Sahara and the great tropical forests. The northern part has a saharian climate and the southern part a tropical one.

The population of Senegal was 3,410,000 persons in 1965. Annual population growth is about 2.3 percent per year.

| | | | |
|------------------------------|------------|-----------|-------|
| The population consists of : | Rural | 2,210,000 | = 65% |
| | semi urban | 230,000 | = 7% |
| | urban | 970,000 | = 28% |

1.2 NOTES ON DAKAR

Dakar, a large modern city of 510,000 inhabitants, may be considered as the capital of West Africa. It has an international airport, a large port, a university granting accredited degrees of the French Ministry of Education, an ethnographic museum, a modern theatre, supermarkets and high rise buildings (up to 16 storeys).

There is a European population of about 10,000 persons.

The city is situated on a volcanic cape attached to the mainland by a strip of sand 3 to 4 km wide. The old city (the European city) is located on the rocky tip. The new city, which includes the "Medina", is located on the isthmus. It may be noted that the new city can only be extended in one direction, thereby increasing the distance between the centre of gravity of the population and the centre of gravity of the activities in the old city (see map).

The attraction of the city on the hinterland makes Dakar's population growth about 6.5 percent per year. Here, as in large cities of underdeveloped countries, the population doubles every 15 years.

The infrastructure is well developed even in the squatter areas. Mass transportation is minimal, but sufficient.

At Dakar, the climate is moderated by the sea. The dry season lasts 9 months and the rainy season lasts 3 months (July, August, September). Humidity extremes range from 45 - 95 percent and temperature extremes from + 15°C (60°F) in January to + 40°C (104°F) in May (see Appendix A).

1.3 AFRICAN DOMESTIC LIFE

African family life is characterized by outdoor living. Verandahs and courtyards are the most used part of the house during the day. A courtyard for men and one for women should be provided. Cooking is always done outdoors over charcoal.

Outdoor life requires ground contact. The need for this is accentuated by the presence of domestic animals (chicken, goats, sheep etc.). The religious sacrifice of sheep is frequent since the majority of the population is Moslim. Therefore it is necessary to anticipate for each family the permanent presence of one or two of these animals, bought at a low price and kept in reserve.

The shutters in the bedrooms are closed permanently, both for protection against the heat and because of superstition.

Polygamy is common. The wives may cohabit or may be dispersed in different parts of the city. Each one of them must have sufficient privacy in common living.

Urban families always lodge several relatives from the country. Also the capacity of rooms in number of beds is maximum. Bunk beds do not exist. Full size beds are the most common type.

The average number of persons per family is 6.3 in Dakar.

1.4 RELIGIOUS LIFE

Religious life is very important, especially for the men since women are not allowed to enter the mosques. The mosque has a social function, taking the place of the cafe in European cities. Mosques are numerous and usually small. They are often constructed by the local residents themselves.

1.5 COMMERCIAL ACTIVITY

The sale of groceries is the exclusive activity of Caucasian arabs, the Maures coming from Mauritania

and the Lebanese coming from the Lebanon. Shops are tiny and stock many products. Bread is sold in pieces; cigarettes are sold individually.

Artisans, principally tailors, shoemakers and blacksmiths, are generally Senegalese.

There are very few cafes.

The African population virtually never goes to the supermarkets. The women go to the open market each morning, where they buy vegetables and fish or meat.

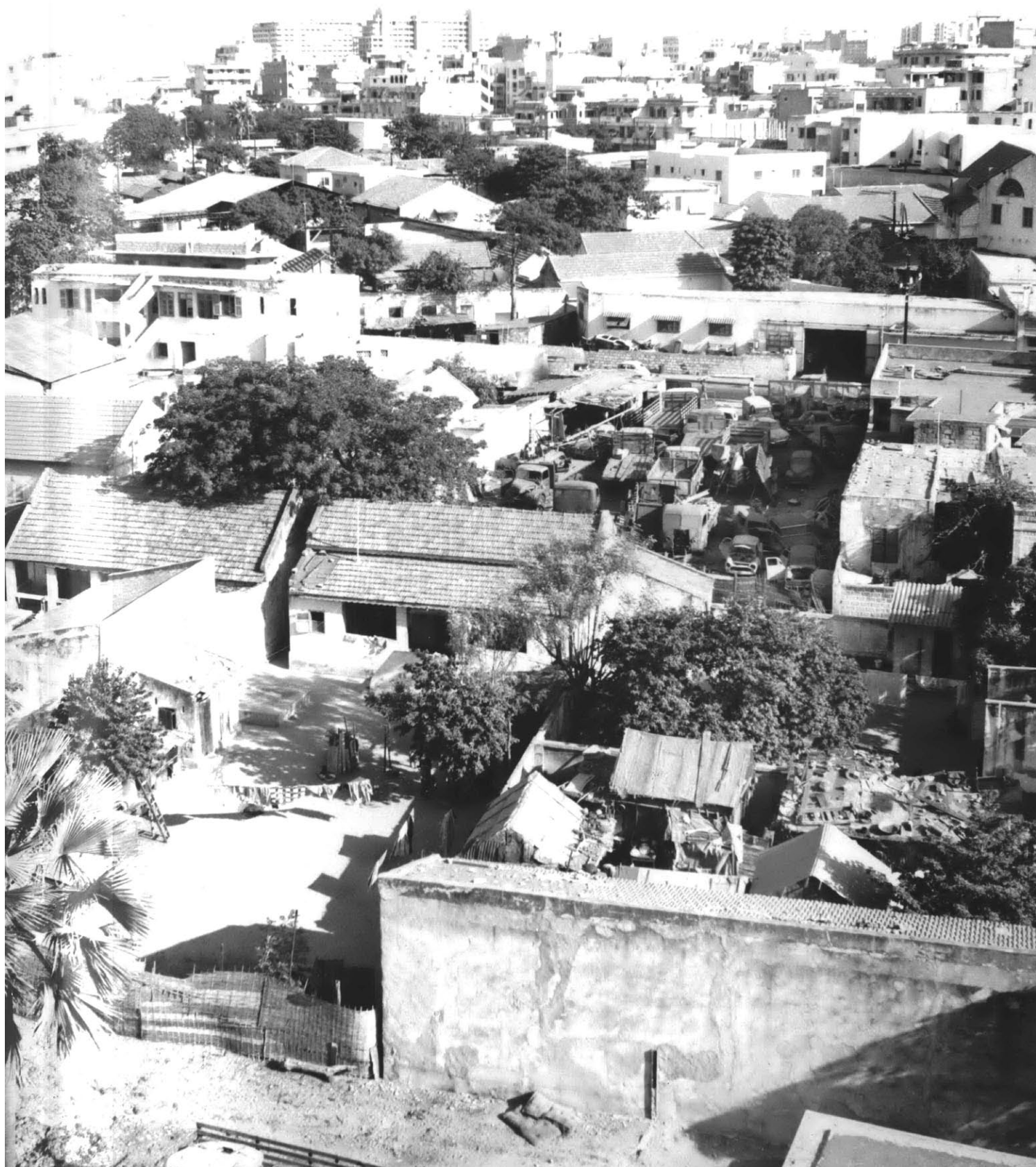
1.6 EMPLOYMENT IN DAKAR

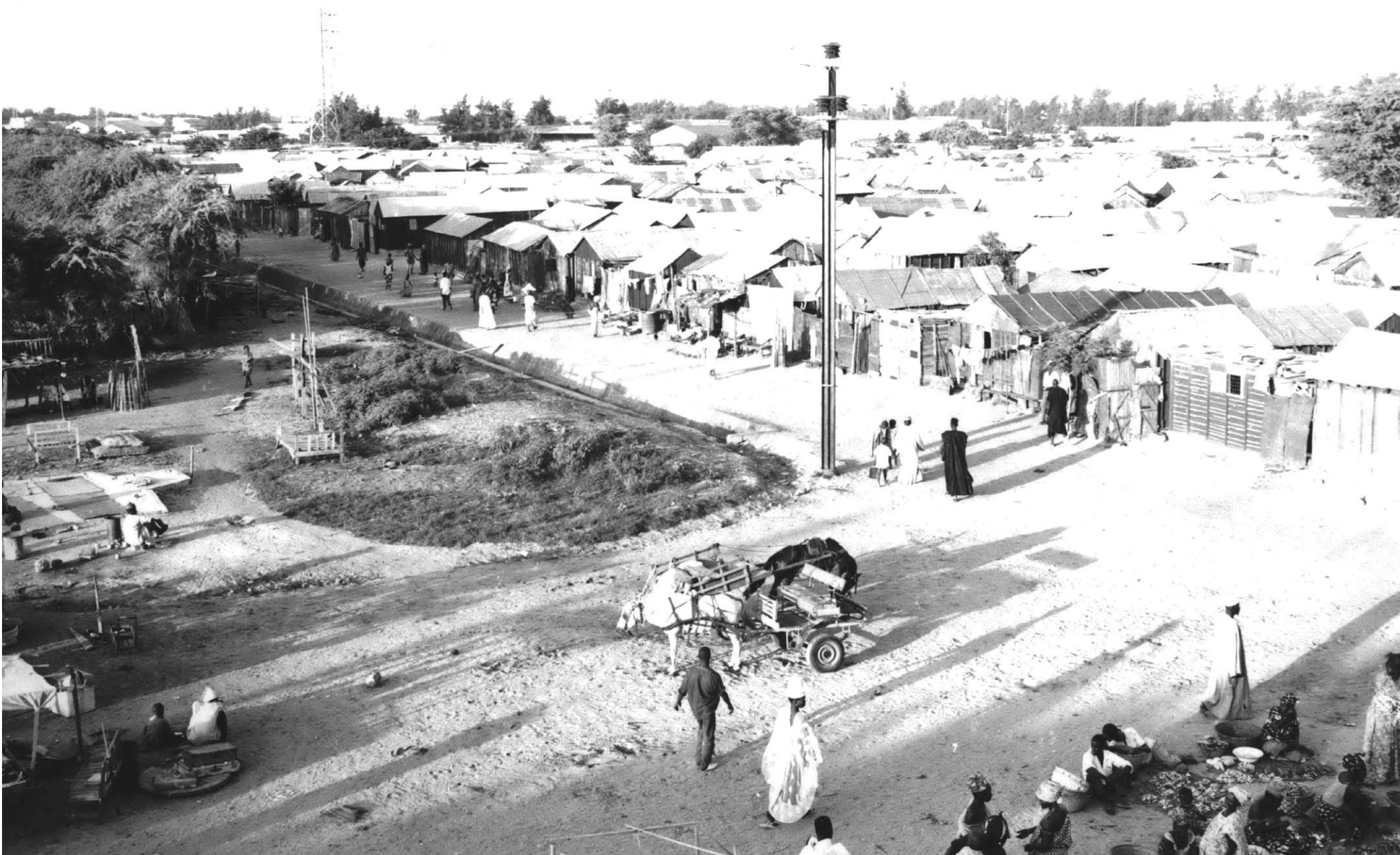
The most common and most desired employment is that of the civil service. The building industry was active in 1964. Most other employment is related with peanut by-products and with the harbour.

PHOTOGRAPHS

- I. General view of the Medina at the border with the modern sections.
2. Notice left a mosque made of a slab on grade covered with mats, a man is praying.
center storm drainage. Transportation with horses.
right open market.
3. Paved street. Butcher shop on the right.
4. Unpaved street. People resting on the street. Typical mason-built house.
5. A line of women waiting for water at a standpipe.
6. Slum conditions.















2. THE HOUSING PROBLEM IN DAKAR

2.1 FIRST APPROACH TO THE HOUSING PROBLEM IN DAKAR

2.1.1 Disparity between income and housing costs

Table I - typical salaries in Dakar

| Monthly salary | FCFA * | Dollars |
|-----------------------------|---------|---------|
| Maid | 8,000 | 32 |
| unskilled labourer | 10,000 | 40 |
| skilled labourer | 15,000 | 60 |
| construction supervisor | 30,000 | 120 |
| civil servant employee | 30,000 | 120 |
| civil servant administrator | 60,000 | 240 |
| government minister | 140,000 | 560 |

* FCFA = Franc Communauté Francophone Africaine.

1 FCFA = 2 FF

Table II - income levels in Dakar

| Monthly family income | | | % of the population | Category |
|-----------------------|-----------|---------|---------------------|----------|
| FCFA | Dollars | average | | |
| 0 - 10,000 | 0 - 40 | 20 | 20 | 1 |
| 10 - 20,000 | 40 - 80 | 60 | 33 | 2 |
| 20 - 30,000 | 80 - 120 | 100 | 21 | 3 |
| 30 - 40,000 | 120 - 160 | 140 | 12 | 4 |
| 40 - 50,000 | 160 - 200 | 180 | 5 | 5 |
| 50 - ... | 200 - ... | 240 | 9 | 6 |

(Rural population, about 65 percent of the total population, has a yearly average income of 17,000 FCFA (US \$ 68), of which 10,000 FCFA (US \$ 40) is placed on the products he grows and consumes himself.)

Table III - theoretical value of housing in dollars

| Average monthly income | % spent on housing | Potential rent | Theor. value of housing* | Cumulative % of the population |
|------------------------|--------------------|----------------|--------------------------|--------------------------------|
| 20 | 10 | 2 | 166 | 20 |
| 60 | 13 | 7.8 | 650 | 53 |
| 100 | 16 | 16 | 1,330 | 74 |
| 140 | 19 | 26.6 | 2,220 | 86 |
| 180 | 22 | 39.6 | 3,300 | 91 |
| 240 | 25 | 60 | 5,000 | 100 |

* Based on a monthly rent of 1.2 percent of the value of the dwelling, showing the amount each family could afford for a dwelling.

Table IV - cost of housing in Dakar

In 1966, the minimum construction cost for the simplest durable house was 10,000 FCFA (US \$ 40) per m² in Dakar.

In such a house, the minimum housing area required is considered to be 6.5 m² per person.

With an average number of 6.3 persons per family in Dakar, the minimum average area of the simplest durable house would be 41 m².

These figures show that the minimum dwelling construction cost for the average family of Dakar is :

$$41 \times 10,000 = 4,10,000 \text{ FCFA (US \$ 1,640)}$$

2.1.2 Conclusions

Comparing Tables III and IV above, we can see that

- A large majority of families (20 percent) lives at the minimum subsistence level. There is no technical solution which would permit them to rent a durable house, no matter how simple the construction.
- For another portion of the population (about 40 percent), it is possible to provide a permanent shelter if the housing cost is lowered by self help improvement and collective plumbing facilities.

- For a third portion of the population (about 30 percent), it is possible to obtain economic housing employing normal construction.
- For the remainder of the population (9 percent) there is no problem of housing.

2.2 SECOND APPROACH TO THE HOUSING PROBLEM IN DAKAR

2.2.1 Investment Possibilities for the Republic of Senegal

Official statistics for Senegal indicate the following figures for 1965 :

Table I

| Population | 1,000,000 | semi urban 230,000 | rural 2,270,000 | Observations |
|--|-----------|-----------------------|--------------------|----------------------------------|
| annual average income per capita in FCFA | 74,000 | 34,800 | 7,050 (+ 10,000 | after taxes self subsistence) |
| investment possibility | 1/6 | 1/8 | | |
| total potential investment funds | 12,350 | 1,000 | | millions FCFA |

Investment decisions taken by the Government of Senegal until now have been the following :

- investment funds in rural areas will mainly be spent on improving tool stocks;
- for urban and semi urban groups, 25 percent

of investment funds will be spent on housing.

This implies that a sum of 3,350 million FCFA can be spent every year on housing.

This amount is to be spent :

- on upkeep of existing housing
 - on replacement of derelict housing
 - on construction of additional new housing
- } new housing

2.2.2 Possibilities of Investment in Additional New Housing

Estimate of upkeep costs of existing housing :

The housing stock in Senegal is considered to be divided so:

Class A - housing of European quality. Usually part of the speculative market

Class B - low cost housing. Usually controlled by the Government.

Class C - permanent housing constructed in towns with primitive means.

Other temporary housing represents only a very small quantity of capital investment.

Funds are divided as follows :

Table 2

| Capital in millions of FCFA | Class A | Class B | Class C | Observations |
|-----------------------------|---------|---------|---------|---|
| | 32,713 | 23,845 | 1,800 | |
| people housed | 62,600 | 142,675 | 100,000 | = 305,275 for a total population of 3.5 million |

by estimating the upkeep cost of houses in classes A B to be 1.5 percent a year, we find an annual upkeep cost of 860 million FCFA. This suggests that possibilities of investment in new houses total :

$$3,350 - 850 = 2,500 \text{ million FCFA.}$$

2) Estimation of the cost of renewing existing housing

If we estimate the cost of A Class house renewal to be 2 percent a year and the cost of renewing B Class houses at 4 percent a year, we find annual renewal cost of 1,610 million FCFA. This suggests that the possibility of investment in additional new houses is :

$$2,500 - 1,610 = 890 \text{ million FCFA.}$$

2.2.3 Conclusion

Does this sum make it possible to accommodate the increase in demand due to the increase in population?

If we want to keep the housing stock the same; that is if it should grow at the same rate as the population (about 2.3 percent a year), and if we consider that there is no longer a market for Class A housing*, then Class B housing stock (C being negligible) should increase by 2.3 percent a year, which means about 550 million FCFA.

* Since independence, a large fraction of the French population has returned to France.

We then notice that :

- The amount that Senegal can invest in improving housing conditions is only :

890 - 550 = 340 million FCFA per year.

This represents about 700 minimum type houses or 500 standard type houses.

In other words, Senegal will only be able to house 500,000 families with inadequate or unhealthy housing after 1,000 years. We must hope that between now and then, prosperity will have improved the investment possibilities of this country.

- The increase in population being 6.5 percent a year in Dakar, almost all the increase in housing stock will need to be built in that town.

2.3 LOW COST HOUSING DEVELOPMENTS IN DAKAR

2.3.1 Data on the Existing Developments

Two important governmental developments are providing low cost housing in Dakar.

1) The "Office des Habitations à Loyer Modéré" was created in 1959. As of 1965, 965 apartments were built in Dakar. The OHLM is financed by a special tax of 2 percent on the general public salaries.

2) The "Société Immobilière du Cap Vert" was created in 1950. As of 1965, 4,866 apartments were built. SICAP infrastructure financing is provided by a subsidy from the French Government.

Housing financing is provided by a loan at an interest rate of 2.5 percent in 10 years, made available through the Common Market.

In this development, the number of apartments built has been decreasing during the last few years and the construction of expensive villas increased.

2,844 apartments are rented for less than 5,000 FCFA a month (US \$ 20). 2,022 apartments are rented for more than 7,000 FCFA a month (US \$ 28). The cheapest rent is 1,400 FCFA a month for one room (US \$ 5.6). The most expensive is 20,000 FCFA for 4 rooms in 1965 (US \$ 80). Some villas are mortgaged for 25,000 FCFA to 44,000 FCFA a month (US \$ 100 - 172) for a fifteen year term.

The lot density is : 36.7 lots per hectare in 1950/60
33.8 lots per hectare in 1960/64.

The construction materials are :

- a metal frame with sheets of corrugated asbestos cement for the roof;

- concrete blocks for the bearing walls;
- concrete slabs and/or tiles (granito) for the floors.

2.3.2 Remarks on the Existing Developments

- 1) Here, as well as in most underdeveloped countries, low cost housing developments benefit only the middle and upper middle classes. Housing taxes paid by every one and subsidies given by foreign countries are distributed only to these classes.
- 2) Houses are generally well built. But on the other hand, the planning of the development is barely studied. Waste of space, arbitrariness and lack of continuity cause these developments to be dull (see photographs).
- 3) Infrastructure costs (a gift from the French Government) separated from housing costs (or what the tenants pay) have resulted in a wrong appreciation of housing costs. If the infrastructure would appear in the costs claimed by the SICAP, and if included in the rent, this development would appear as a very expensive one.
- 4) Low urban density will soon result in the subdivision and the sub-renting of lots, causing slum conditions.

5) Low densities cause a high maintenance cost of the infrastructure.

Nevertheless, these developments show the real desire of the Senegalese Government to improve the housing stock of the country and to solve the social problems caused by the slum conditions in the old Medina.

The Developments have already changed the appearance of the city and contribute to the modern and dynamic look of Dakar.



CHANTIER
SICA
LOTISSEMENT
AMITIE

3. PROPOSED DEVELOPMENT AND PROPOSED SYSTEM OF CONSTRUCTION

3.1 THE HOUSING PROGRAM

3.1.1 The Developer

In countries of West Africa, the "Collectivity" has always been responsible for housing and community design. It carries in fact most of the responsibility for providing a shelter for the poorest classes.

But jobs ^{run} by the Government or by Government Agencies tend to be slow and costly. Methods of letting projects out for bids and methods of payment to contractors are the primary factors for slowing the process of construction. This is especially true in a country like Senegal, where the self proliferating administration has aggravated the faults of the former French administration.

In order to avoid these inconveniences we could plan an urban development carried out in its totality by a private developer linked to the Government by a special type of contract.

The developer, a "bureau d'étude privé" would be responsible for the erection of the development. The contract could also include the installment of the occupants.

The difficulties of this method would not be a result of its novelty but of the choice of the developer and the contractors. All Senegalese contractors at present have clearly demonstrated that they are unable to carry out important undertakings, usually because of their lack of financial assets, managing capacities and technological ability. Most of them would have to be eliminated when putting projects out for bids. This would create difficult problems because European companies are still considered as a product of the colonialization.

In spite of these problems, I am suggesting a restricted participation by the administration, with an emphasis on the participation of European developers and contractors.

This problem is above all a political one, and it depends on the Government to solve it in accordance with its objectives.

3.1.2 The size of the Development

As we saw in part 2.2.2, possibilities for investment in new housing for Senegal are 2,500 million FCFA per year.

Taking into account :

- the costs shown in Table IV,
- that houses should be built outside Dakar,
- that houses should be built by private enterprises,
- that houses will continue to be built by the SICAP and the OHLM,

it seems advisable that this development should be limited to an initial stage of 800 or 1,000 units built over 30 to 36 months.

If the methods discussed here are successful, the number of units could be doubled in a second operation.

3.1.3 The Financing

I propose that we should eliminate a financing based on the levy on general public salaries, which is now in force in Senegal. A general housing levy on salaries is in fact a disguised tax.

I eliminate also the present possibility of a partial financing through subsidies by a foreign government,

since this falsifies real costs of construction without helping the population as a whole. Subsidies should rather be used for education, health, agriculture and industry investments.

Therefore the two sources of financing are :

- (a) a financing through the nation's "Budget d'Equipement"
- (b) a financing through the "Fonds d'Aide et de Cooperation" (France) and the "Caisse Centrale de Cooperation Economique" (Common Market). The rates would be :
 - for 1/3 of the loan 5.5 percent over 5 years
 - for 2/3 of the loan 3.5 percent over 15 years, starting the 6th year.

3.1.4 Methods of Development

Question of land ownership :

Most city planners who have worked in West Africa propose renting of land on long term leases and private ownership of the housing.

Land has, in fact, been kept generally in collective status. The public authority grants concessions which require low payments. The collectivization of non-developed urban land is a valuable principle which reduces financial speculation.

But it is questionable whether collectivization of developed land is still a valuable principle. The small number of durable houses built in Dakar by private Senegalese initiative may be a result of the fact that the inhabitants do not own the land on which they are housed. Safety in ownership is an important factor in determining private investment. Wouldn't private ownership of lots encourage the inhabitants to improve their condition of housing?

This leads to the proposition of emphasizing the necessary business of finding ways for the occupants to become owners of land and housing in this development.

One can note that :

- a new development is designed to last a long time.
That is, for at least 50 years titles to land will not trouble large scale collective projects.
- if the real costs - infrastructure, construction, debt amortization - are imposed on the buyers, land speculation would become less profitable.
- If the lots are small enough not to exceed the needs of a family, we will not find later subrenting of the land. 120 m^2 is an average limit that should not be exceeded. Large lots always produce new slums through subdivision.

Question of possibilities for family investment :

As has been shown in Table III, family funds are generally very scarce. Senegalese families save little money and cannot obtain bank loans at present. Only higher level civil servants have possibilities for obtaining long term financing (maximum 15 years, rates above 10 percent).

The opposition between the necessity of ownership and the scarcity of long term financing leads to the following propositions :

- (a) mortgage purchase (see also Appendix 2) : This system requires a guarantee of sufficient and stable family income. Unfortunately it does not seem possible to mortgage to anyone except higher level government and privately employed people, whose salaries are sufficient to insure complete repayment within 15 years.
- (b) self help : This method is based on the occupant's participation in the construction of his own dwelling unit. This participation consists of purchase by the occupant of all or part of the construction materials, which he then utilizes with the help of a local builder or mason. Construction of this type proceeds depending on the means of the occupant. A certain amount of public

education will be needed. It should be noted that the occupant's participation in the construction of his own house is important psychologically since the results depend on his own initiative and not on the state.

The following table shows the financial advantages of this particular solution. The cost of self help housing is 77 percent of the cost of the housing built by a contractor. The table shows also that communal sanitary facilities allows an additional 14 percent saving.

| Costs | Contractor percent | Self Help percent | Self Help with comm. sanitary facilities % |
|---------------------|--------------------|-------------------|--|
| Land (public) | 0 | 0 | 0 |
| Materials | 33 | 33 | 28 |
| Labour | 22 | 10 | 8 |
| Administration | 6 | 7 | 7 |
| Profit (contractor) | 15 | 7 | 7 |
| Water | } 24 | 20 | } 4 |
| Sewage | | | |
| Electricity | | | } 9 |
| Roads etc. | | | |
| Total | 100 % | 77 % | 63 % |

Note: financing costs have not been included. They should increase the difference between the final totals.

3.1.5 The System of Development

In the light of the above considerations, and in particular those of paragraphs 2.1 and 2.2.3, it appears that the only means for providing housing for the largest part of the population is as follows (and which will be further detailed) :

- (a) For the lowest economical level, an open lot in a subdivision equipped with infrastructure and communal sanitary facilities.
- (b) For the category immediately above, corresponding more or less to categories 2 and 3 of Table II, a lot in a subdivision equipped with infrastructure and communal sanitary facilities. This lot will include an unfinished covered structure provided by the developer. This will serve as a shelter for the family, who will be able to complete it with partitions, doors, windows and wall finishes.
- (c) For higher categories, a lot in a subdivision equipped with infrastructure, including a low cost house provided by the developer. Two different standards will be available. A basic one with common sanitary facilities, called "minimal unit", and a more expensive one with plumbing called "non-minimal unit". Each of these standards will contain different types of varied areas.

Categories 5 and 6 will be able to either benefit from the above systems or undertake their own construction privately on land reserved for selling for private uses.

The development of a light, prefabricated system, studied in detail later in this report, should allow us to obtain these objectives, while maintaining overall architectural logic and unity.

Certain proposals may seem unrealistic since they have never been tried. But to attempt to solve this timeless social problem of housing for the poor classes is a revolutionary enterprise.

As such, its realization is political and is closely related to government objectives.

3.1.6 The Site

The proposed location of the development is at a place called "Grand Dakar", nearby the recent governmental developments.

It comprises an area of almost 20 hectares, west of the Avenue de la Liberte, in the triangle of streets Nos. 10 and 13.

The development will occupy a small part of this area, which could be later developed on the same model, as well as the sections of the Medina along the "autoroute".

FEUILLE NORD



The existing constructions are most wood and tin shacks. Solid houses only represent a negligible capital.

The population - slightly the same number as the housing capacity of the new development - could move temporarily their shacks into the empty areas between street No. 13 and the autoroute.

The moved people would have a priority in the occupancy of the new shelters.

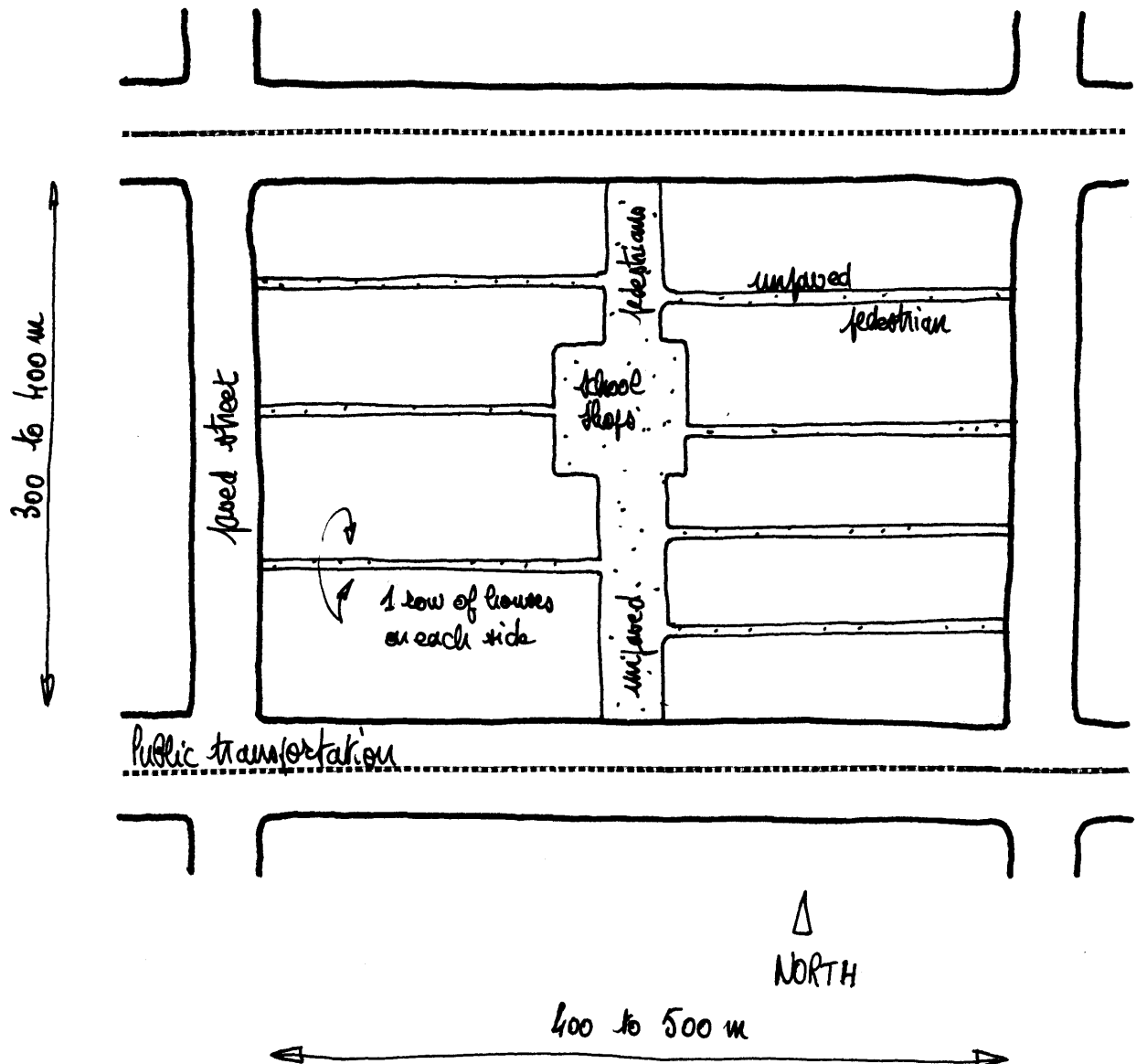
3.2 A PRELIMINARY STUDY

During the preliminary study the following points were emphasized :

(a) The community design :

- The building rows will be aligned on an east/west orientation.
- Only the main streets will be paved (the site is almost completely flat). The existing soil is sandy and will be used for all other circulation. These minor circulation pathways are mostly pedestrian, but may be used by cars.
- Building rows are long to reduce the cost of infrastructure (utilities and party walls).
- 2 storey houses are close to paved streets where main water and sewage lines run.

- The pattern of circulation in the community is as follows :



- Squatter lots are integrated with the other types of housing to encourage the occupants to improve their housing conditions and to avoid social segregation through housing quality segregation.

(b) The study of units :

- In the duplex unit, the stairs are built outside the enclosed area. This provides three important advantages :

1. Economy in partition walls and roof area;
2. Reduction of the width of the bay; and
3. Simplification in the joist distribution.

These advantages seem to outweigh the disadvantage of circulation through a bedroom. Bedrooms are of secondary importance in the family life.

- The module is fixed at 60 cm. This dimension is related to the size of component materials listed in Appendix 3.
- The minimum width of 3.6 m is of great importance in the units with plumbing, since it reduces the lot cost of infrastructure utilities. The units without plumbing have widths from 3.6 m for the efficiency, to $3 \times 3.6 = 10.8$ m for the 4 bedroom unit.
- Two places should be provided for family life: one for men and one for women and children. The backyard, which is the cooking area, will certainly be the women's living

area. Men can gather in the living room, which is in certain units enlarged by a small frontyard.

- The entrance to the toilet should be outside the enclosed area.
- The closets are used as thermal insulation on outside walls. Cross ventilation is always to be provided in the bedrooms.
- Since doors and windows are expensive, they have to be reduced to a minimum, compatible with good ventilation (there is always enough light). It is possible to use a door-window combination: 2 operable sashes, each 60 cm wide, one of which will normally remain closed, with fixed glass in the upper two-thirds.

(c) The study of a light weight prefabricated system

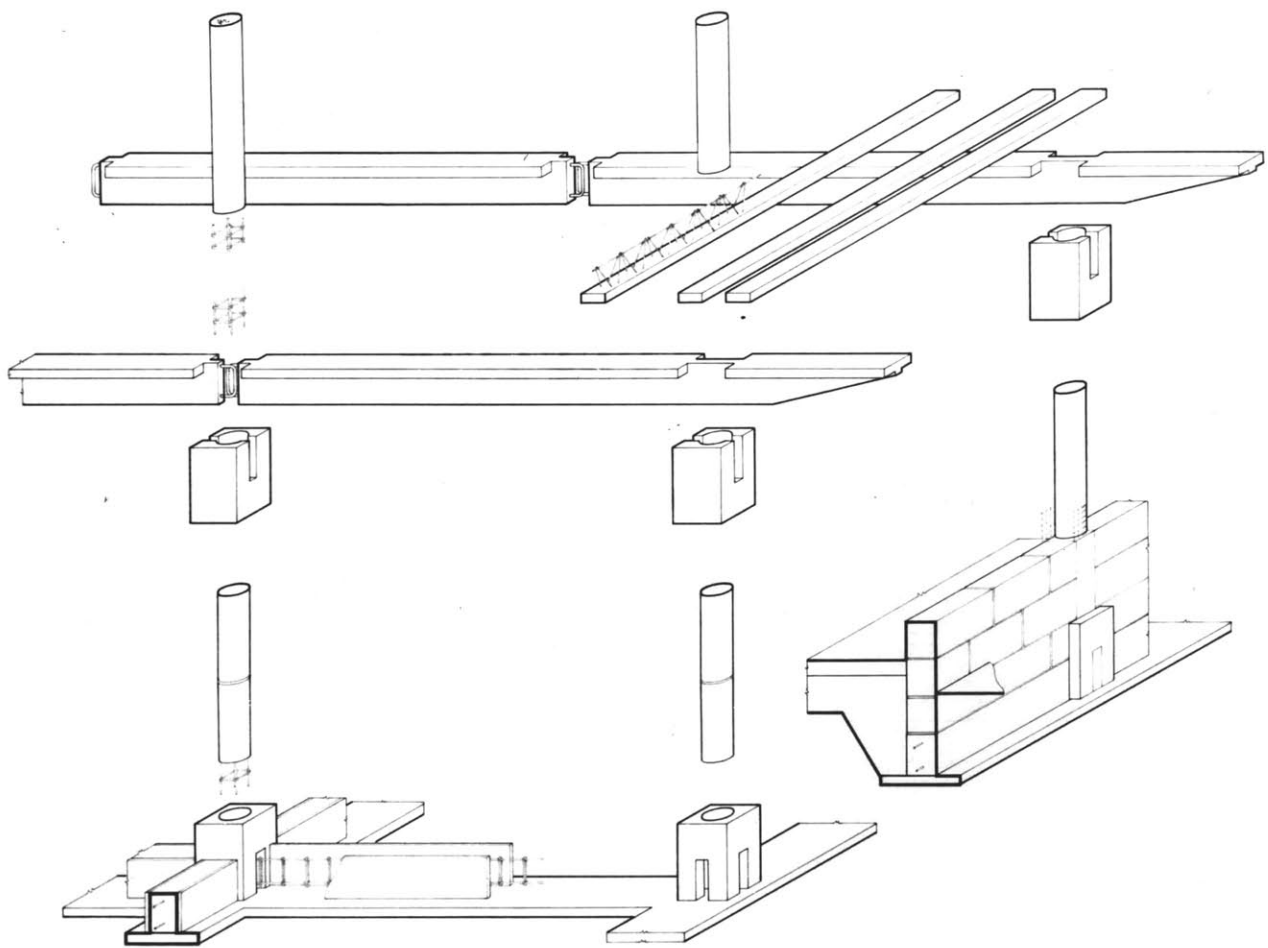
- The bay width is 3.6 m; this is an efficient span for the joists. It is 2.4 m deep to reduce the weight of the beam and the amount of steel reinforcing.
- A solid concrete column is too heavy to be carried by two men. To make it hollow would be too complicated. Therefore, asbestos-cement pipes can be used as columns. They can be filled with low quality concrete without reinforcing bars.
- The system called "variation" uses the same mold for the columns and the beams. Each piece is slightly lighter than those in the preceding system. But it will require much more concrete and will not be developed further.

PHOTOGRAPHS

Study of two systems of construction. Drawings and models.

Last photograph: welded reinforcements for self supporting joists.

middle and bottom: System OMNIA.

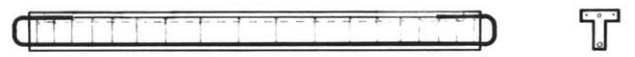


1 ASBESTOS CEMENT PIPE 25 KG

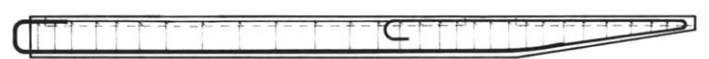
2 CONNECTION DICE 40 KG



3 BEAM 110 KG



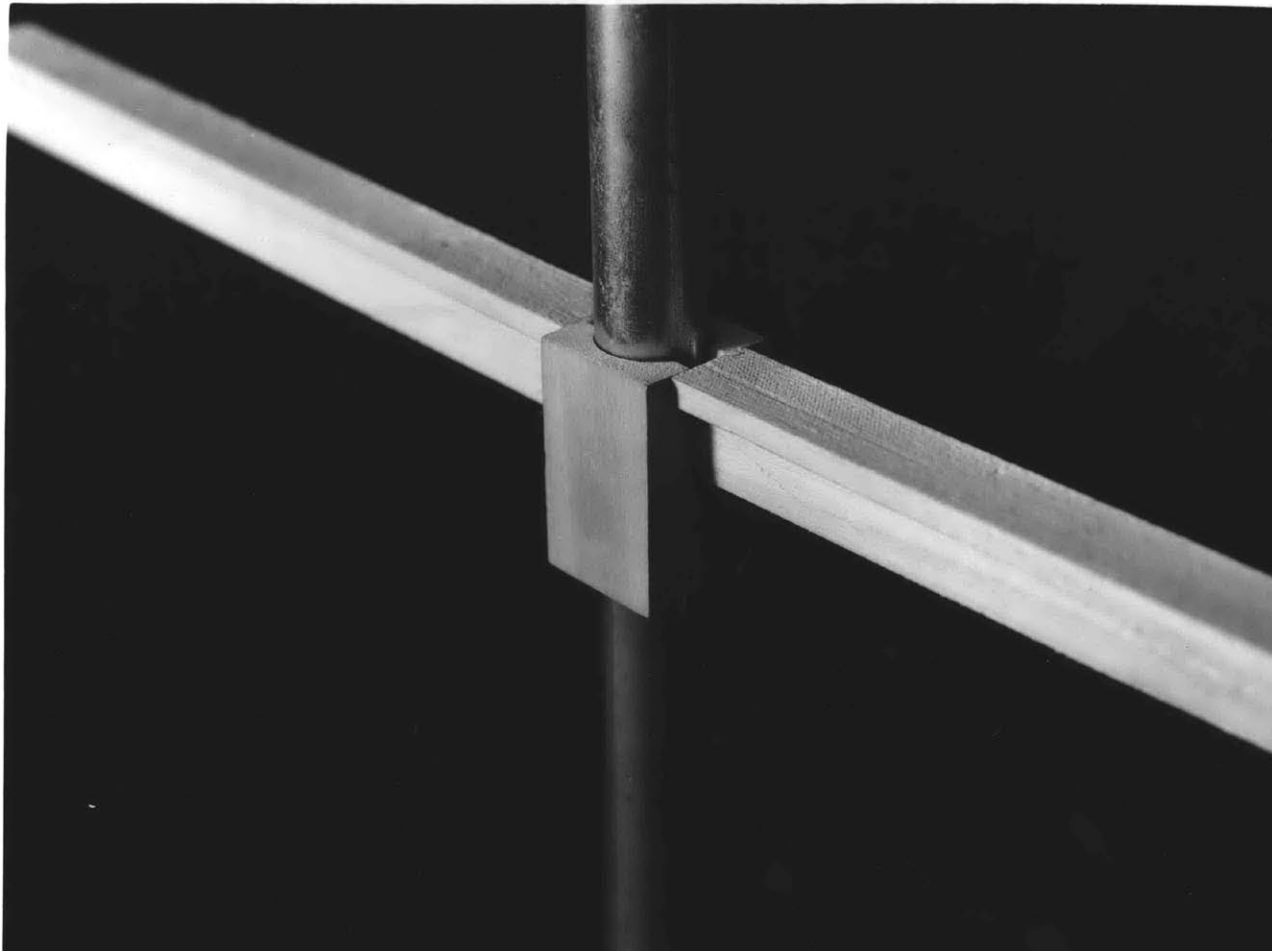
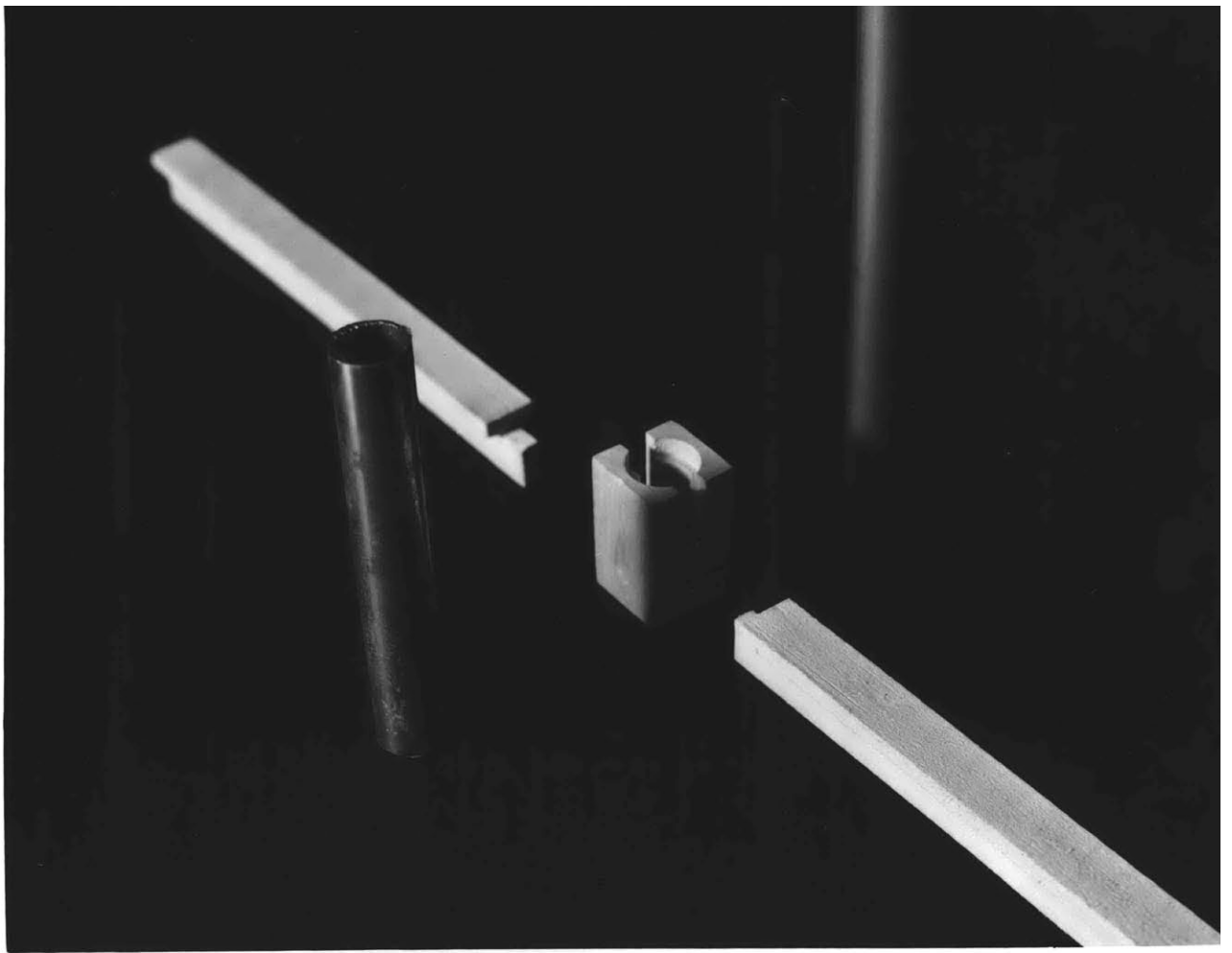
4 BEAM WITH CONSOLE 130 KG

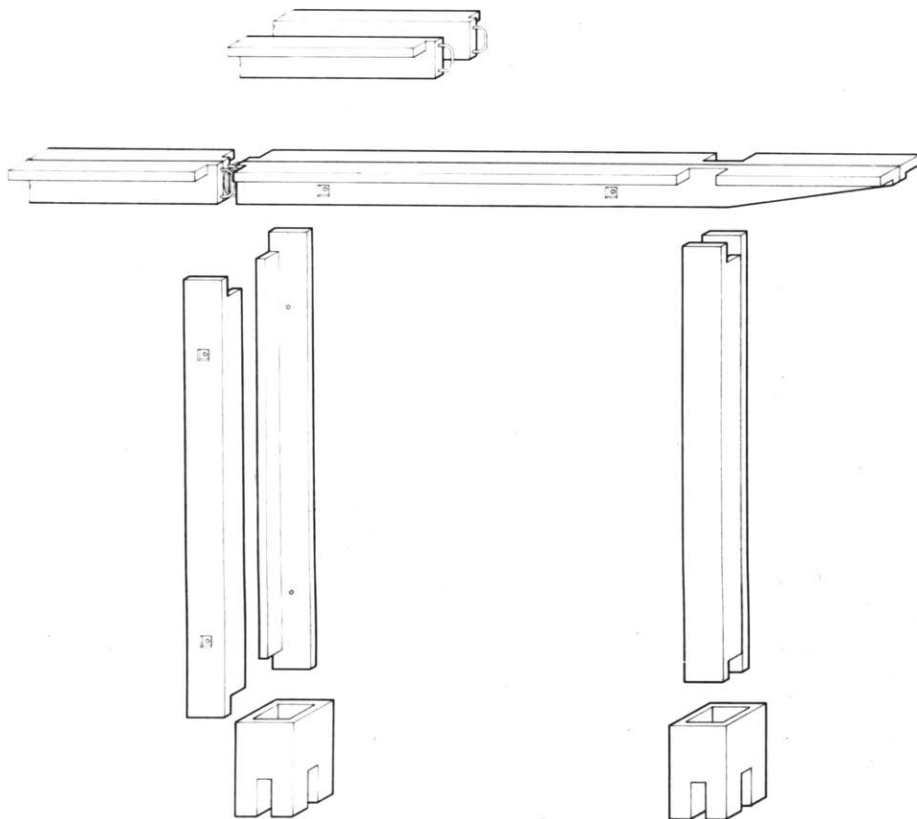


5 JOIST 58 KG



A LIGHT WEIGHT PREFABRICATED SYSTEM





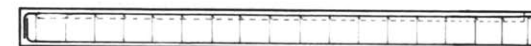
STRUCTURAL BAY



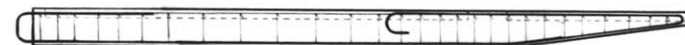
1 BEAM 2 PIECES EACH 86 KG



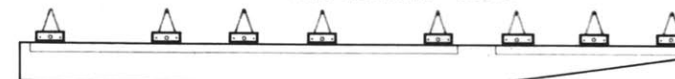
2 COLUMN 2 PIECES EACH 100 KG



3 BEAM WITH CONSOLE 2 PIECES EACH 116 KG



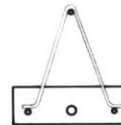
4 JOIST JOIST DISTRIBUTION 48 KG



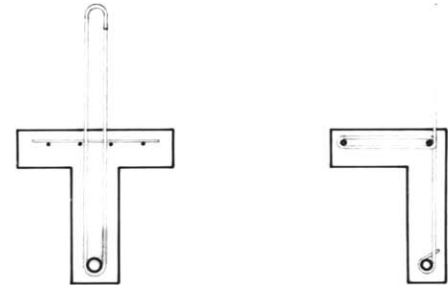
5 CONNECTION DIE 46 KG

VARIATION

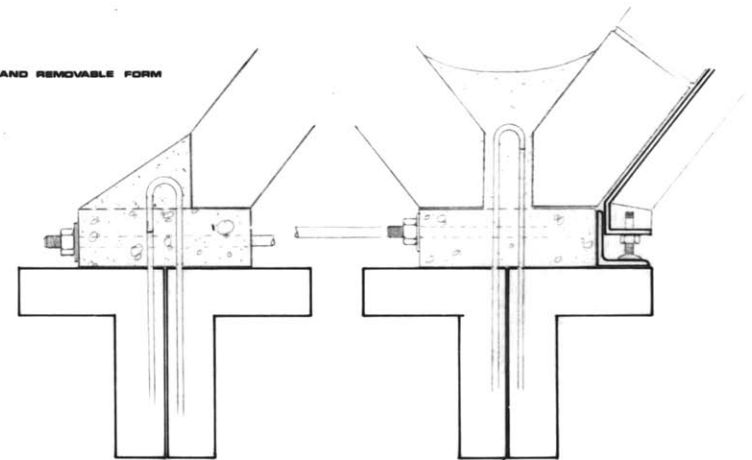
JOIST SECTION

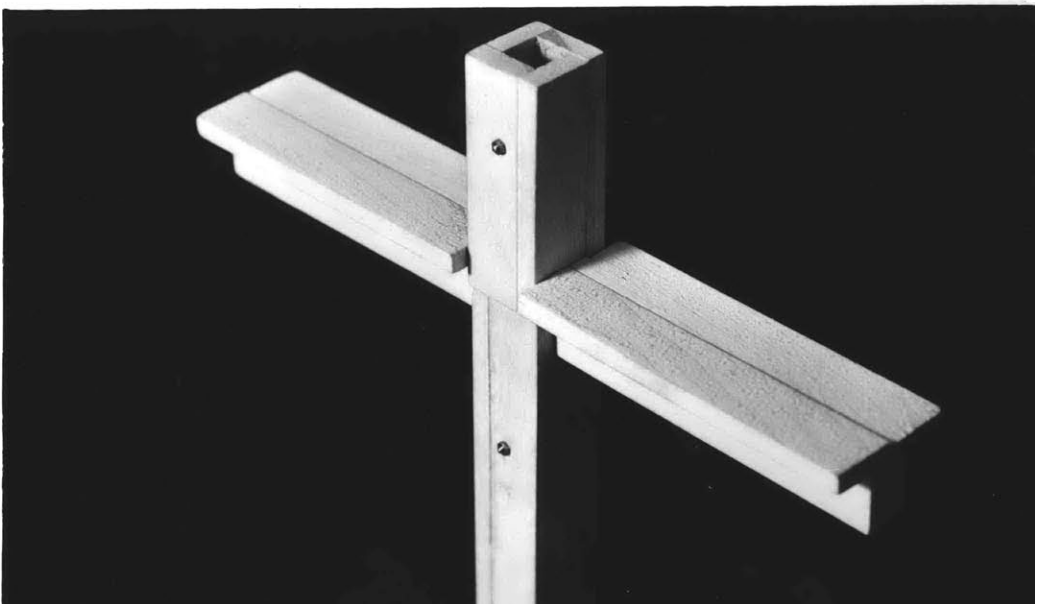
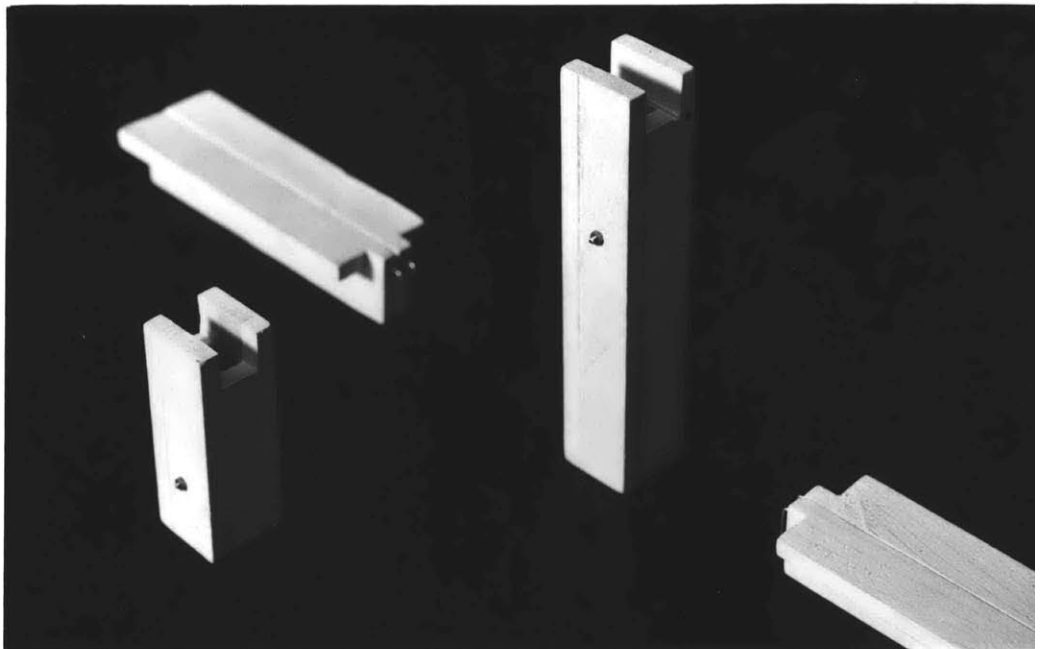
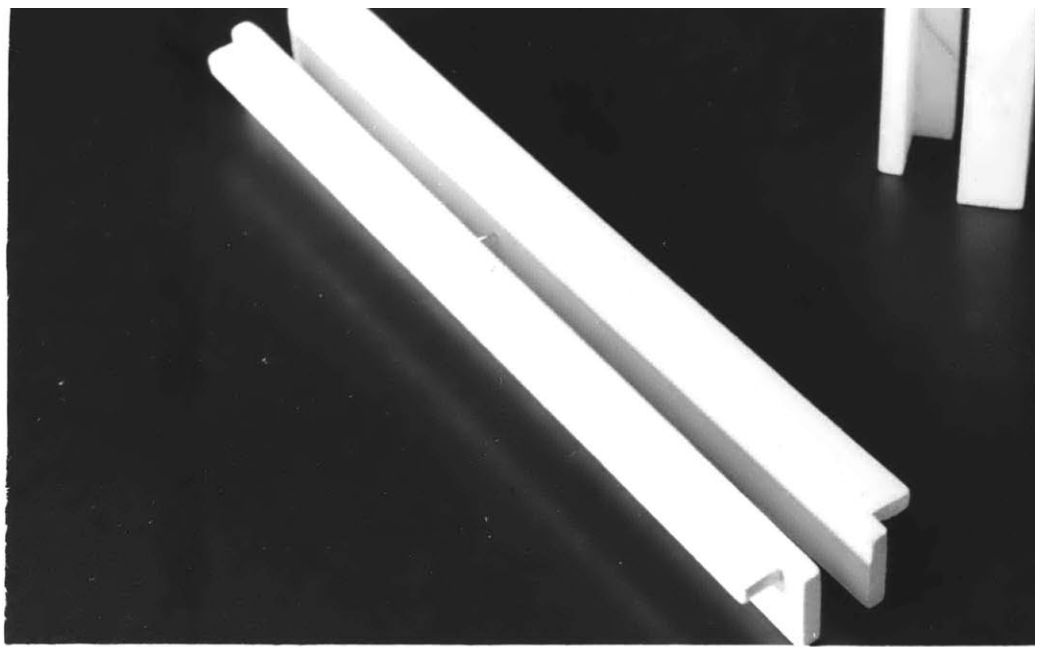


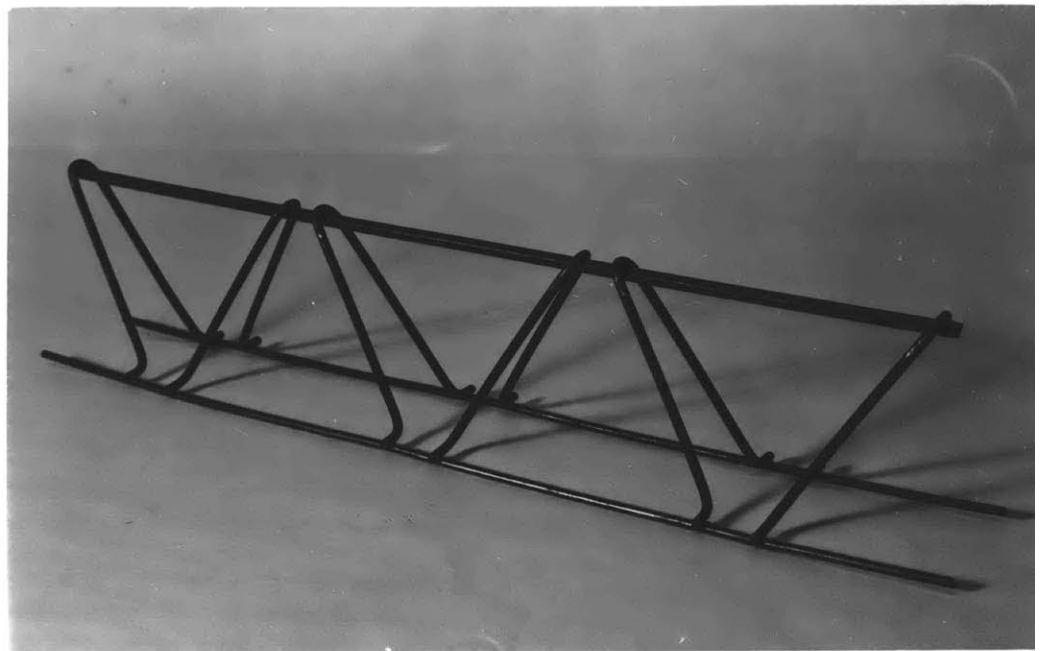
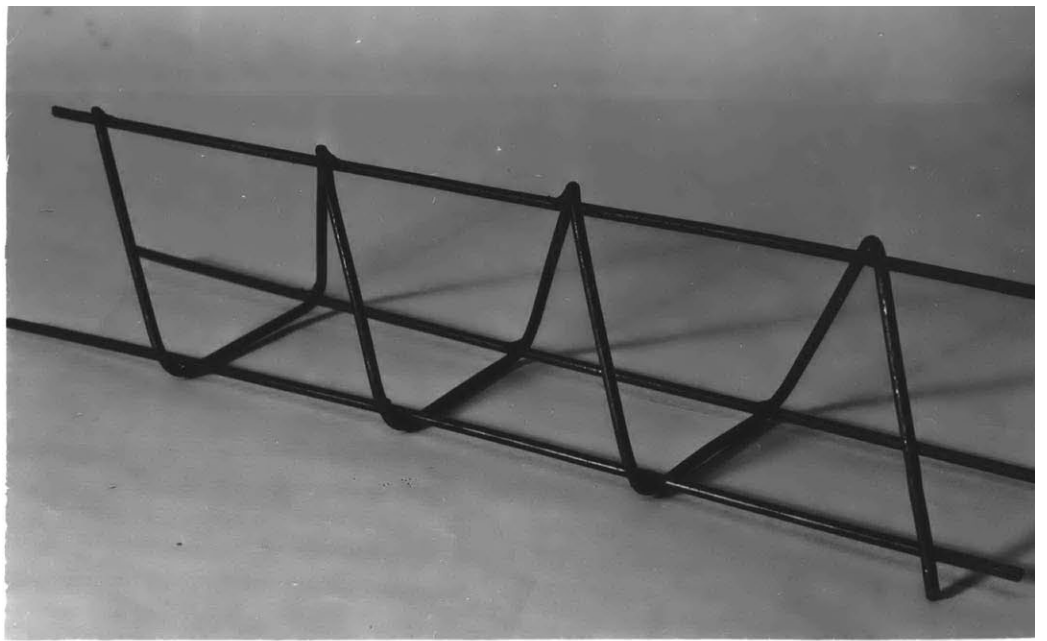
BEAM SECTION



BRICK VAULT TIE AND REMOVABLE FORM







3.3 THE COMMUNITY

3.3.1 The size of the community

As we saw in paragraph 3.2.2., the initial stage of development should be limited to 800 to 1,000 dwelling units. This initial stage of development corresponds to the size of an efficient elementary school (7 to 15 years) :

In fact the efficient size of an elementary school in developing countries is close to 1,000 children. 18 percent of the population in Dakar being between 7 to 15 years old, the size of the related development would be :

$$\frac{1,000 \times 100}{18\%} = 5,500 \text{ inhabitants}$$

$$\frac{5,500}{6.3 \text{ pers/fam}} = 800 \text{ families}$$

$$= 800 \text{ dwelling units.}$$

With the lot density proposed in the next paragraph we find that the area occupied by this development would be :

$$18.6 \text{ hectares or } 186,000 \text{ m}^2.$$

The walking distance to a focus (generally a mosque and a few artisan shops) will not exceed 300 meters.

Consequently this initial stage of development will be a self sufficient community organized around a focus or several foci composed of primary schools,

the elementary school, mosques, artisan shops and open markets.

Higher education facilities and non-basic commercial activities (supermarket, furniture etc.) will be found in the existing facilities of Dakar.

3.3.2 The lot density

The large cities in underdeveloped countries and especially Dakar suffer from too-low urban densities. Present developments with densities of 35 lots per hectare are equivalent to the densities of western middle class suburbs.

For an underdeveloped country, urban development to be economic should not have less than 50 lots per hectare and the area of the lots should not be less than 60 percent of the total area.

There is a general tendency to want to increase lot dimensions, which leads to increase the cost of infrastructure, transportation and commuting time.

For example: for 50 lots per hectare the infrastructure costs 50 percent of the cost of housing; for 30 lots per hectare the infrastructure costs 100 percent of the cost of the housing.

Therefore I propose in this study to have a density of 60 lots per hectare with 60 percent of the land occupied by the lots.

I propose also to emphasize the construction of two storey buildings. African urban population is used to living in one-storey housing. Two-storey housing with duplex apartments would be an important transition between horizontal and vertical housing, which is the solution to the necessary increase of population density.

3.3.3 Facilities related to the community

| | Number | Area m ² | Observations |
|--------------------|--------|------------------------|--------------------------------|
| Centre social | 1 | 1,200 | with kindergarten (2/5) (1) |
| Dispensaire | 1 | 300 | |
| Ecoles maternelles | 2 | 3,375 | primary (4/7) (2) |
| Ecole primaire | 1 | 14,600 | elementary (8/16) (3) |
| Playgrounds | | 8,000 | |
| Sports area | 1 | 8,000 | |
| Open market | 1 | 500 | |
| Artisan shops | | 500 | |
| Admin. sub centre | 1 | 300 | |

(1) for 100 children.

(2) 10 percent of the population between 4 and 7.

1/2 of the children go to school. 225 each.

(3) 1,000 children. 9/10 of the children go to school.

3.4 THE HOUSING SYSTEM

3.4.1 The prefabrication system

The study of a prefabricated system has been based on two important ideas :

- (a) The existence of an asbestos-cement plant in Dakar. This implies an important use of that material.
- (b) The possibility of self help construction. This implies that every prefabricated piece can be carried by two men without too much difficulty. In other words, no piece must exceed 150 kg. This implies also that the system must be as simple as possible:
 - no structural piece has to be poured in place;
 - self-supporting beams and joists allow to avoid shores;
 - the house can be constructed in several years, room by room.

We should also remember that :

- there is a brickyard which provides hollow bricks for walls and roofs and solid bricks for the floors.
- that wood is scarce and expensive as well as steel.

3.4.2 Materials

Column : a standard asbestos-cement pipe. Interior diameter 150 mm.

Beam : concrete, wires sticking out of top for pouring after joists are placed.

Joist : the welded truss of reinforcing rods give enough strength to support the floor with only one shore in the middle of the span.

Infill : either concrete, brick or asbestos-cement.

A light prefabricated coffer can be made out of standard flat or corrugated asbestos-cement sheets. 4 cm of concrete with a mesh on top. Span 40 to 60 cm.

Roofing: either a brick vault or a regular flat roof made with joists. The system depends upon the skill of the labourer (contractor or self help).

An alternate solution is possible for the beam (length 2.3 m) with an asbestos-cement mold cut in a flat standard sheet (length 2.5 m). The asbestos-cement in tension will allow to reduce the section of the steel. The contractor could study the advantage of having this mold poured in place, but a delay of 7 days would be required before placing the joists and the infills.

3.4.3 Housing types

The overall development is based on a 2.4 x 3.6 m grid.

- (a) Squatter lots. The squatter lots are 2 bays (or 7.2 m) wide and enclosed by a solid fence. The areas vary between 75 and 125 m². Any kind of housing can be built on these lots. However it is expected that the occupants will buy pieces of the prefabrication system at a low price from the contractor making them under a governmental agreement. One or 2 storey houses can be built. But since labour is relatively unskilled, 1 storey types would be predominant.

- (b) Lots with a structure. These lots are equipped by the contractor, within the development contract, with a prefabricated structure. This structure is unfinished; only the party walls and exterior walls are provided. The occupant will provide the partition walls, plastering, doors and windows, the floor and the electrical wiring. He is expected to use stabilized earth for the partition walls. Most of the structures of this type will be one storey.

- (c) Lots with a minimal unit. This so called "unit" is a complete dwelling without plumbing facilities. Water and sewage, as in the preceding types, can be installed later by the occupants. The development's main water and sewage lines are built to allow easy extension.

The widths of this type of unit can be 1 to 3 bays. All dwellings in the same row would be equal in width.

In all preceding dwelling types, sanitary facilities with showers, toilets and washing facilities are shared.

- (d) Lots with a non-minimal unit. This unit is a 2 storey duplex dwelling with plumbing facilities. It is always 1 bay in width. Its length varies from 3 to 4 bays with the possibility of having a cantilevered balcony.

The stairs are light, prefabricated elements which cover a space for bicycles and garbage cans.

3.4.4 Table of costs - contractor construction - dollars

| Type of dwelling | Cost per m2 | | Area m2 | | Purchase price | % on the total |
|--|--------------|----|--------------|----|----------------|----------------|
| | lot dwelling | | lot dwelling | | | |
| <u>squatter</u> | 4 | | 75 125 | | 300 500 | 25 |
| <u>minimal unit structure only</u> | 4 | 28 | | | | 25 |
| sleeps 2 | | | 64 | 30 | 1,100 | |
| " 4 | | | 95 | 45 | 1,640 | |
| " 7-8 | | | 125 | 63 | 2,260 | |
| " 9-10 | | | 155 | 81 | 2,880 | |
| " 15-16 | | | 182 | 95 | 3,390 | |
| <u>Minimal unit finished</u> | 4 | 36 | | | | 25 |
| sleeps 2 | | | 64 | 30 | 1,330 | |
| " 4 | | | 95 | 45 | 2,000 | |
| " 7-8 | | | 125 | 63 | 2,770 | |
| " 9-10 | | | 155 | 81 | 3,560 | |
| " 15-16 | | | 182 | 95 | 4,240 | |
| <u>Non-minimal unit structure only</u> | 8 | 46 | | | | 10 |
| sleeps 5 | | | 84 | 48 | 2,870 | |
| " 7 | | | 93 | 58 | 3,420 | |
| " 9 | | | 100 | 67 | 3,880 | |
| <u>Non-minimal unit finished</u> | 8 | 54 | | | | 15 |
| sleeps 5 | | | 84 | 48 | 3,270 | |
| " 7 | | | 93 | 58 | 3,880 | |
| " 9 | | | 100 | 67 | 4,420 | |

Note: Self help construction would lower these costs to
77 percent of the current values.

Comparison with Table III of paragraph 2.1.1 shows that there is still a section of the population that cannot even buy a lot of 75 m2.

PHOTOGRAPHS

Project,

Model of the system of construction,

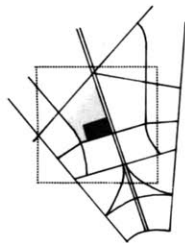
Model of a house:

a structure being self helped.

Model of the community:

mall, artisan shpps, mosque, communal facilities, pedestrain
circulations, squatter constructions in open lots (nº 2),
housing.

COMMUNITY AND SITE PLAN



HOUSING



COMMERCIAL
AND RECREATION



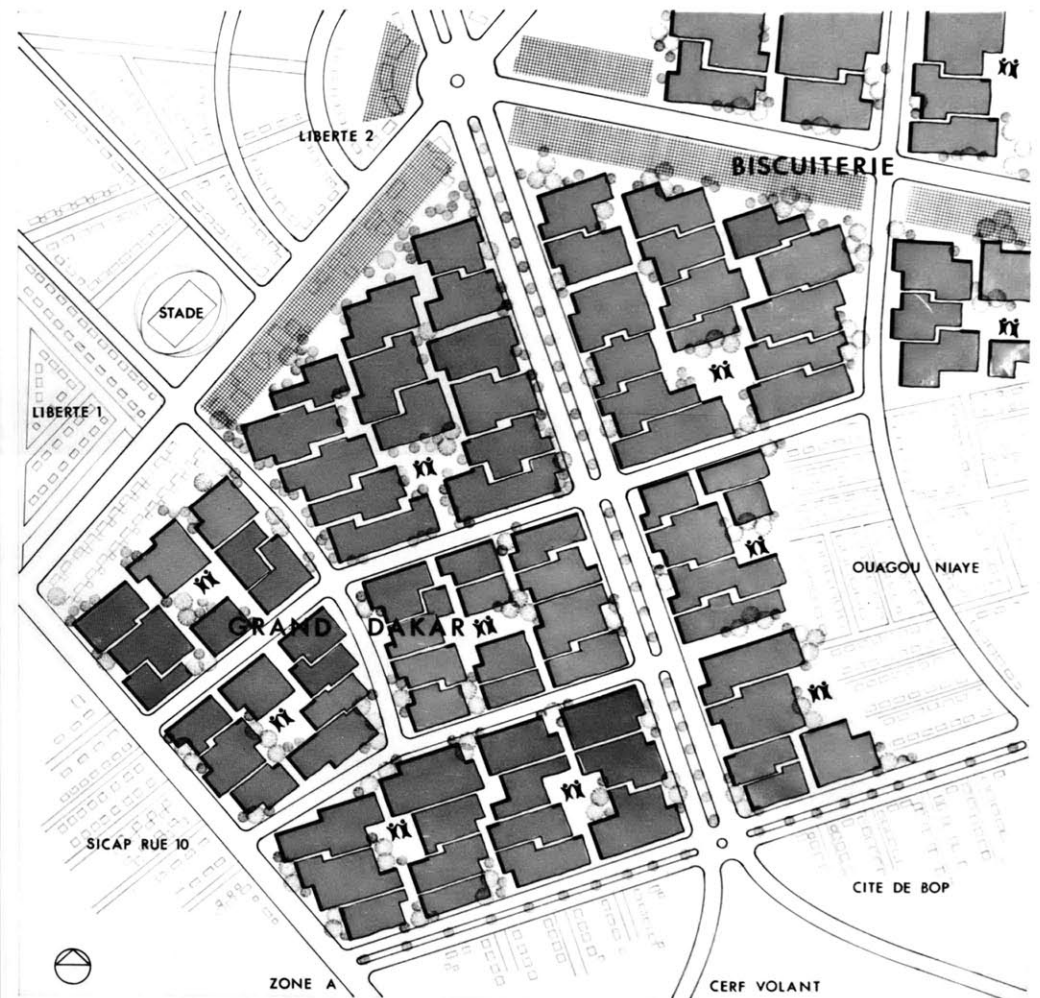
PRIMARY SCHOOL

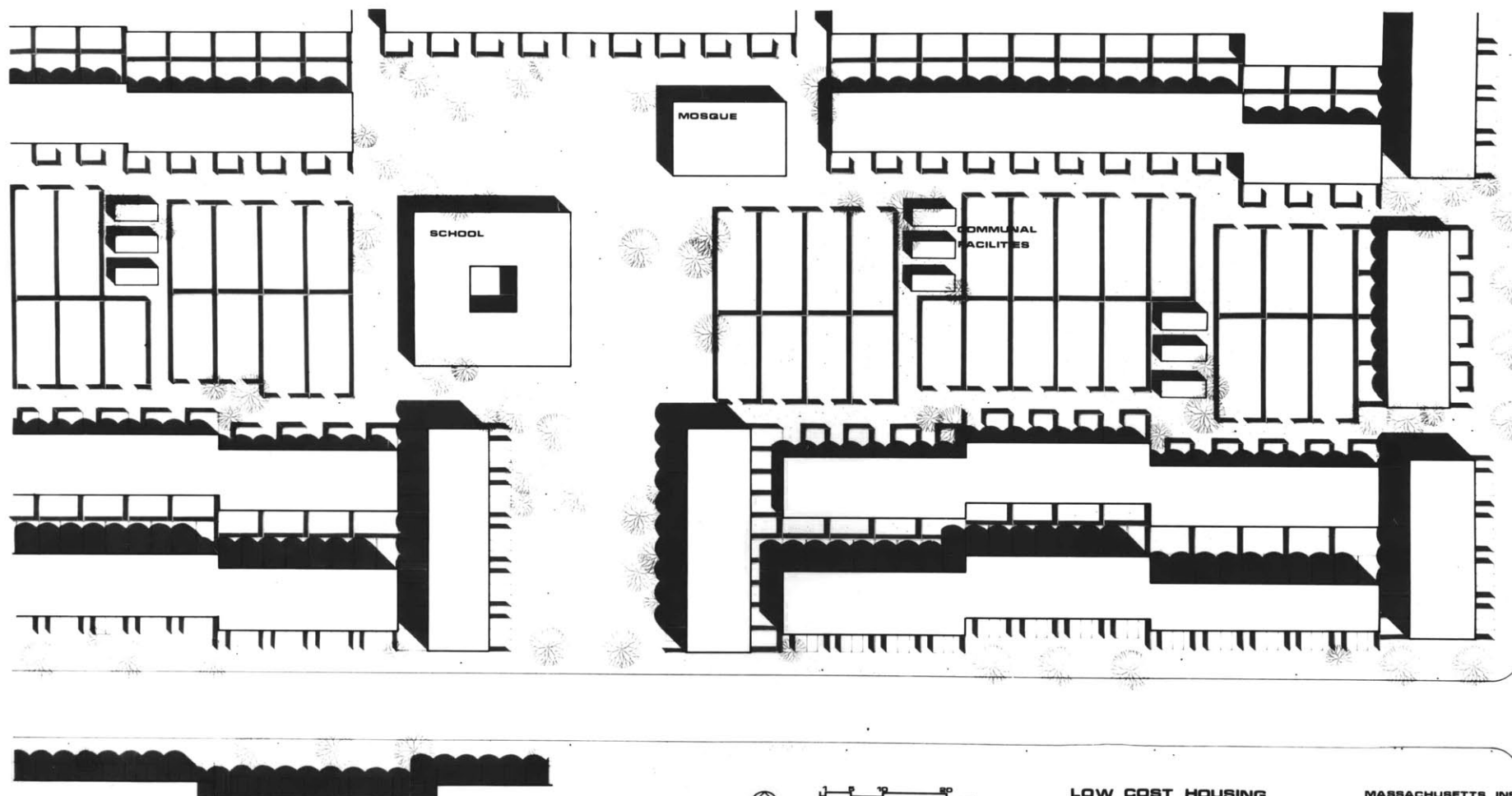


LOW COST HOUSING
IN WEST AFRICA

DEVELOPMENT PLAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MASTER IN ARCHITECTURE THESIS
GERARD COURTIEUX JUNE 1987





SHEET 2



1 2 3 4 5 6 7 8 9 10
SITE PLAN

LOW COST HOUSING
IN WEST AFRICA

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MASTER IN ARCHITECTURE THESIS
GERARD COURTIEUX
JUNE 1967

58 M²
93 M²

48 M²
84 M²

87 M²
100 M²

ENCLOSED AREA
LOT AREA

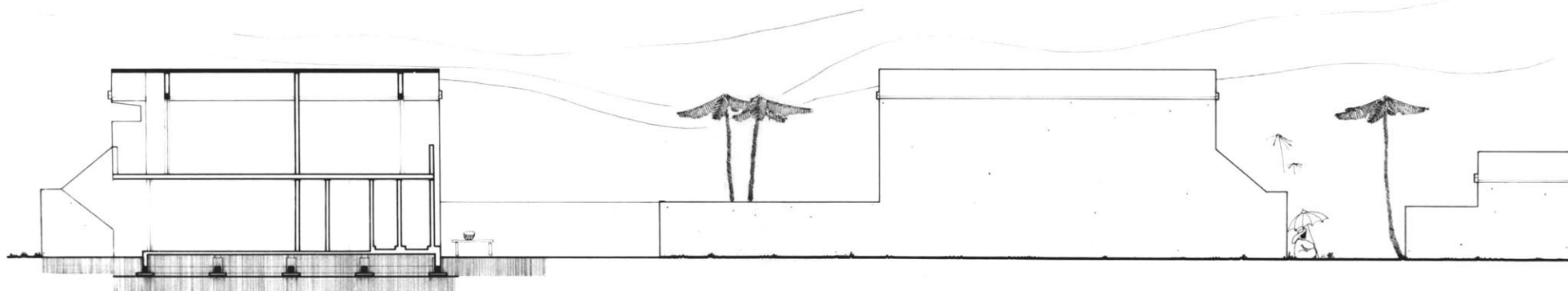
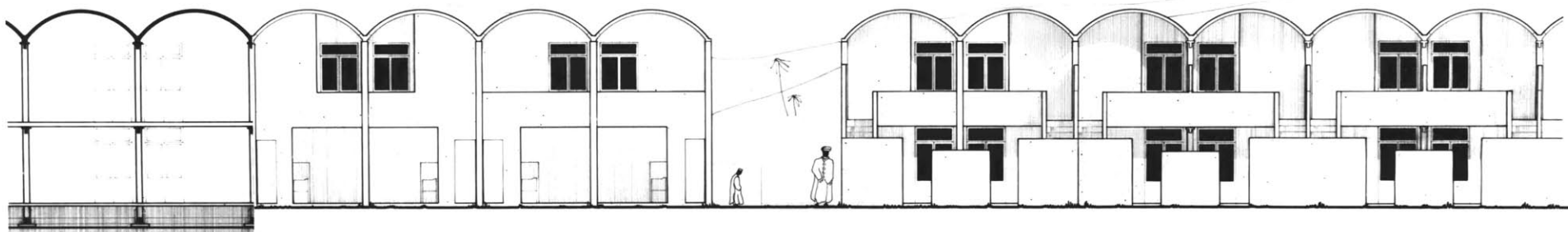
1ST FLOOR

2ND FLOOR

TYPICAL PLANS : NON-MINIMAL UNITS

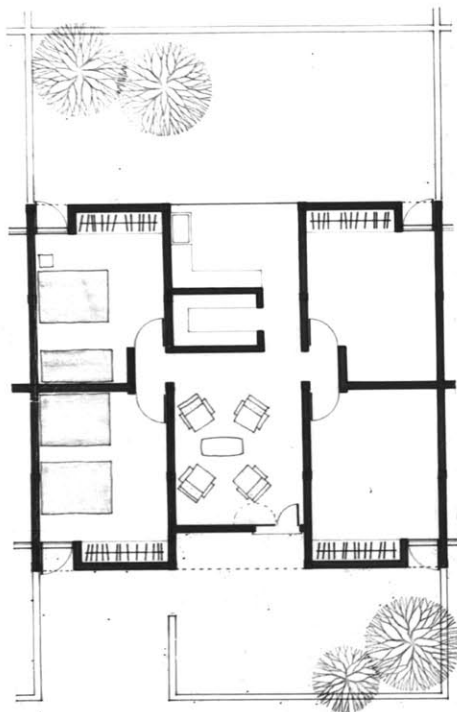
LOW COST HOUSING
IN WEST AFRICA

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MASTER IN ARCHITECTURE THESIS
GERARD COURTIEUX JUNE 1987



95 M² 5 ROOMS
192 M²

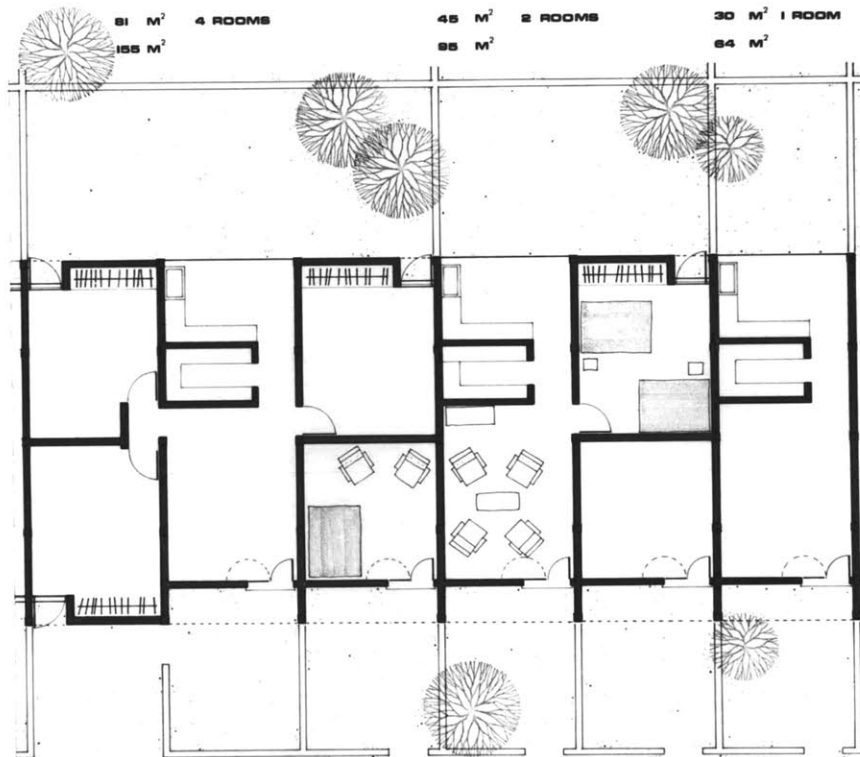
ENCLOSED AREA
LOT AREA



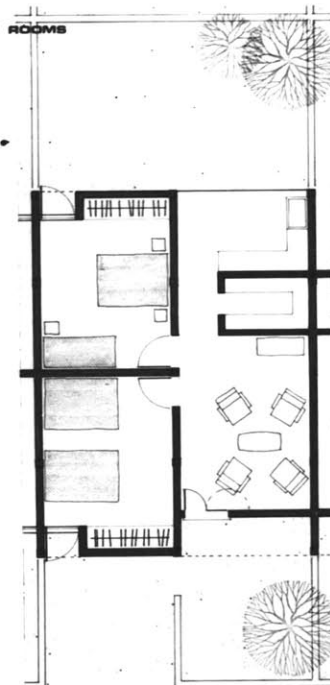
81 M² 4 ROOMS
155 M²

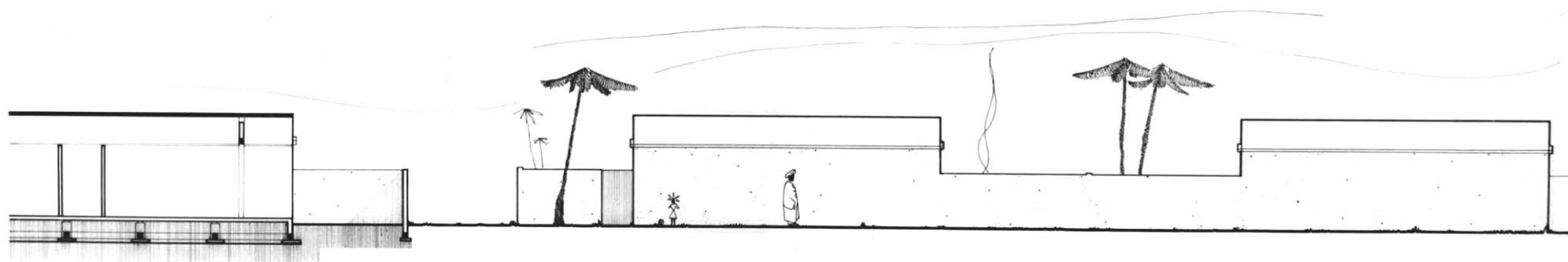
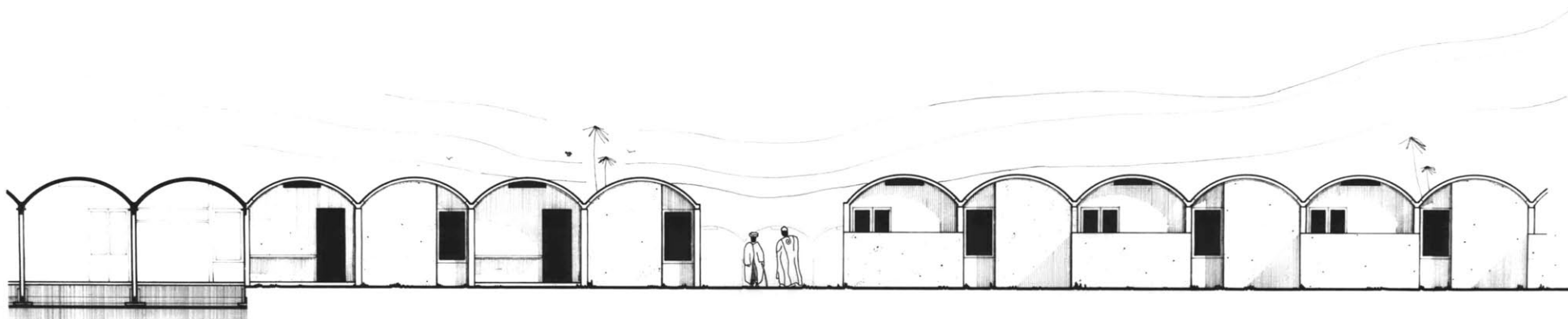
45 M² 2 ROOMS
95 M²

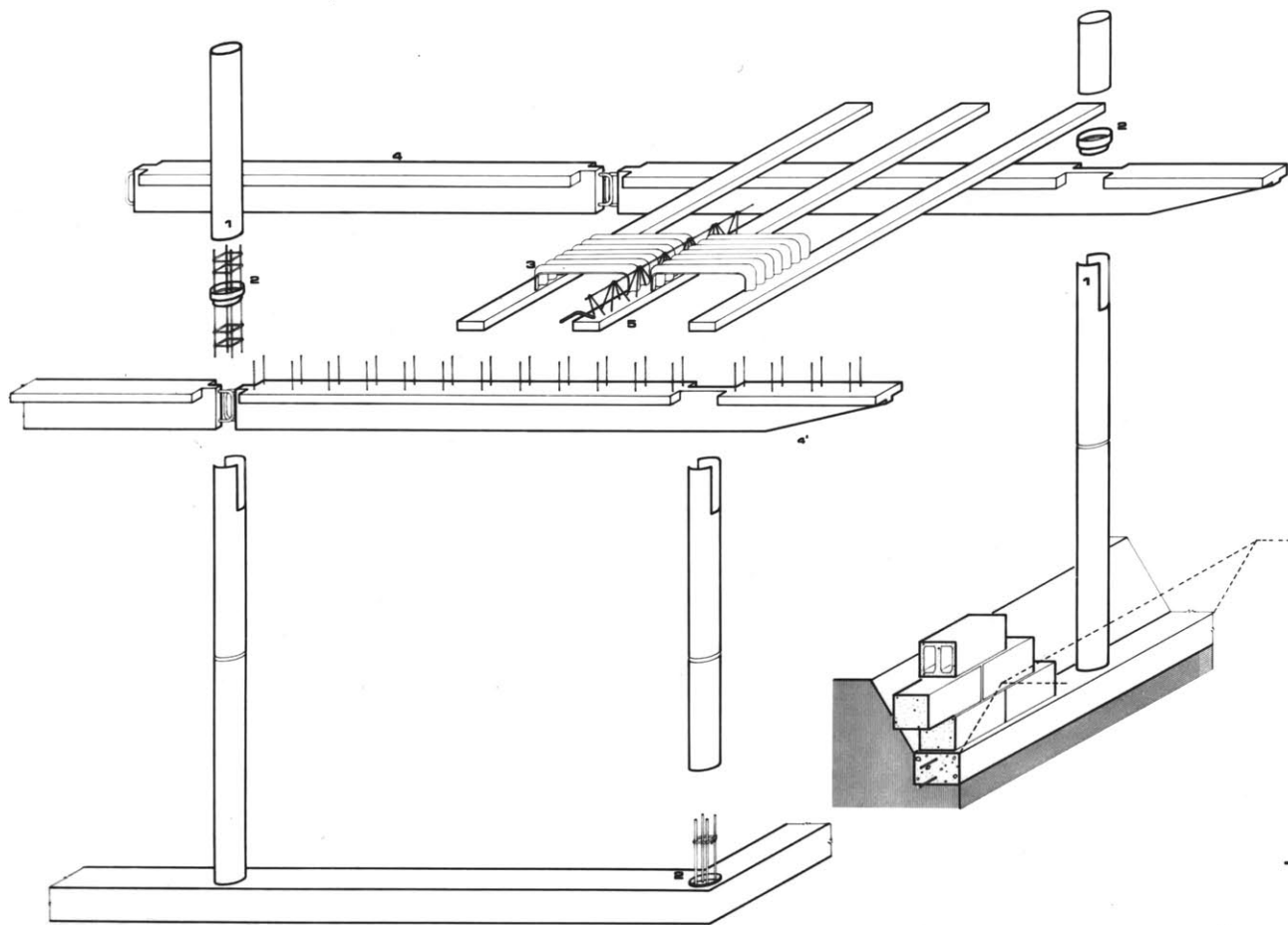
30 M² 1 ROOM
64 M²



63 M² 3 ROOMS
125 M²







1 ASBESTOS CEMENT PIPE

2 ASBESTOS CEMENT FITTING



3 ASBESTOS CEMENT PAN



4 BEAM WITH CANTILEVER 4'



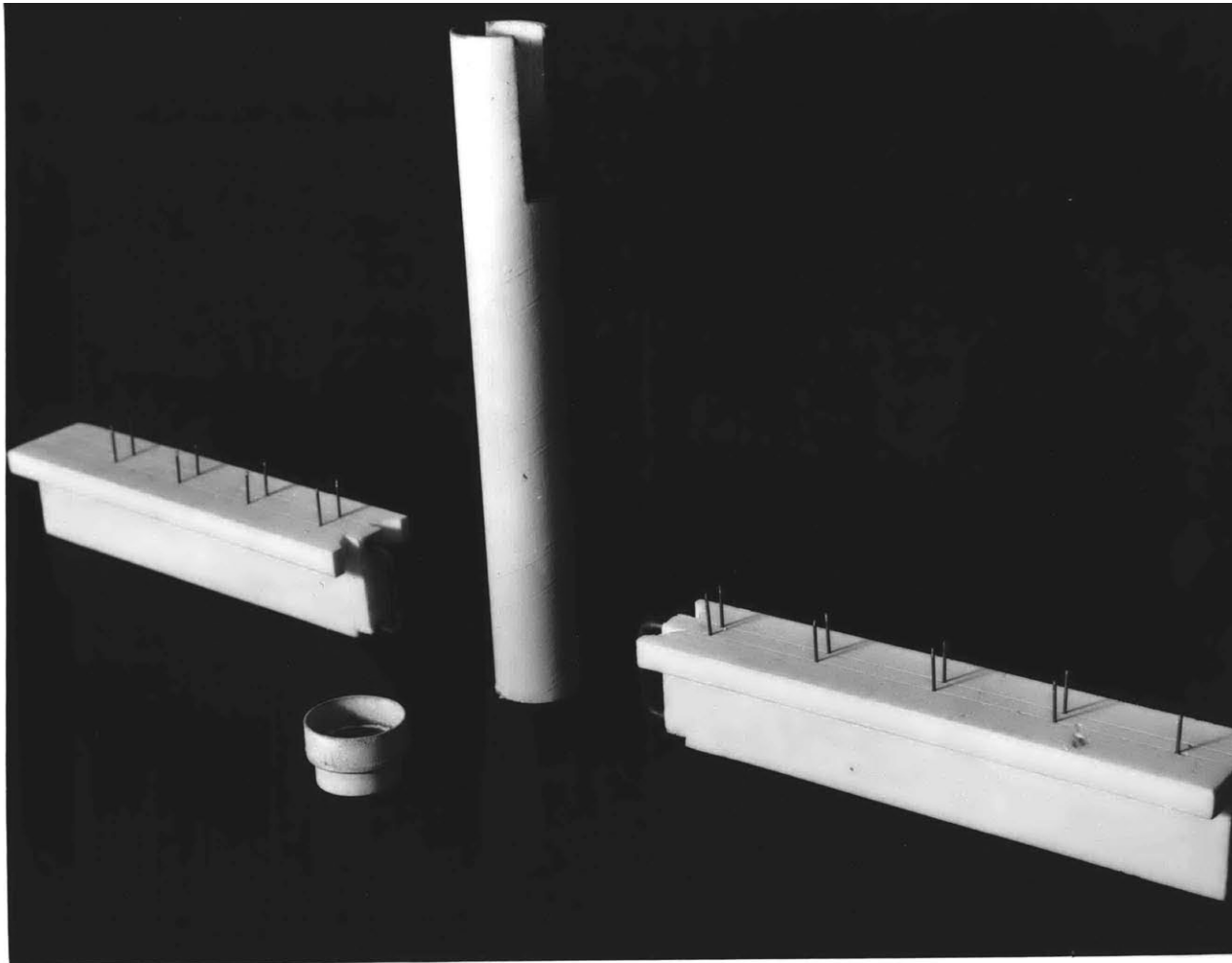
5 JOIST

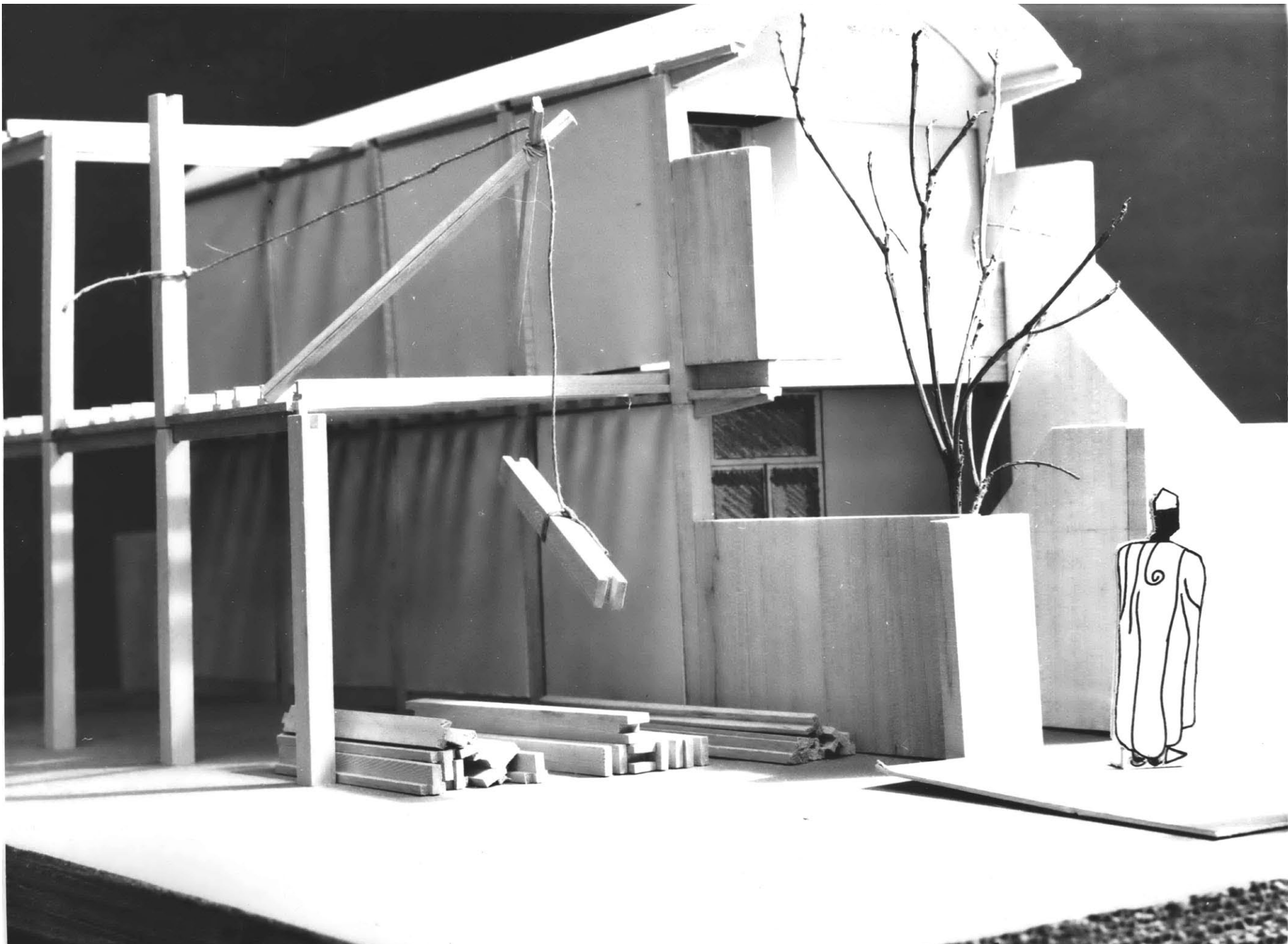


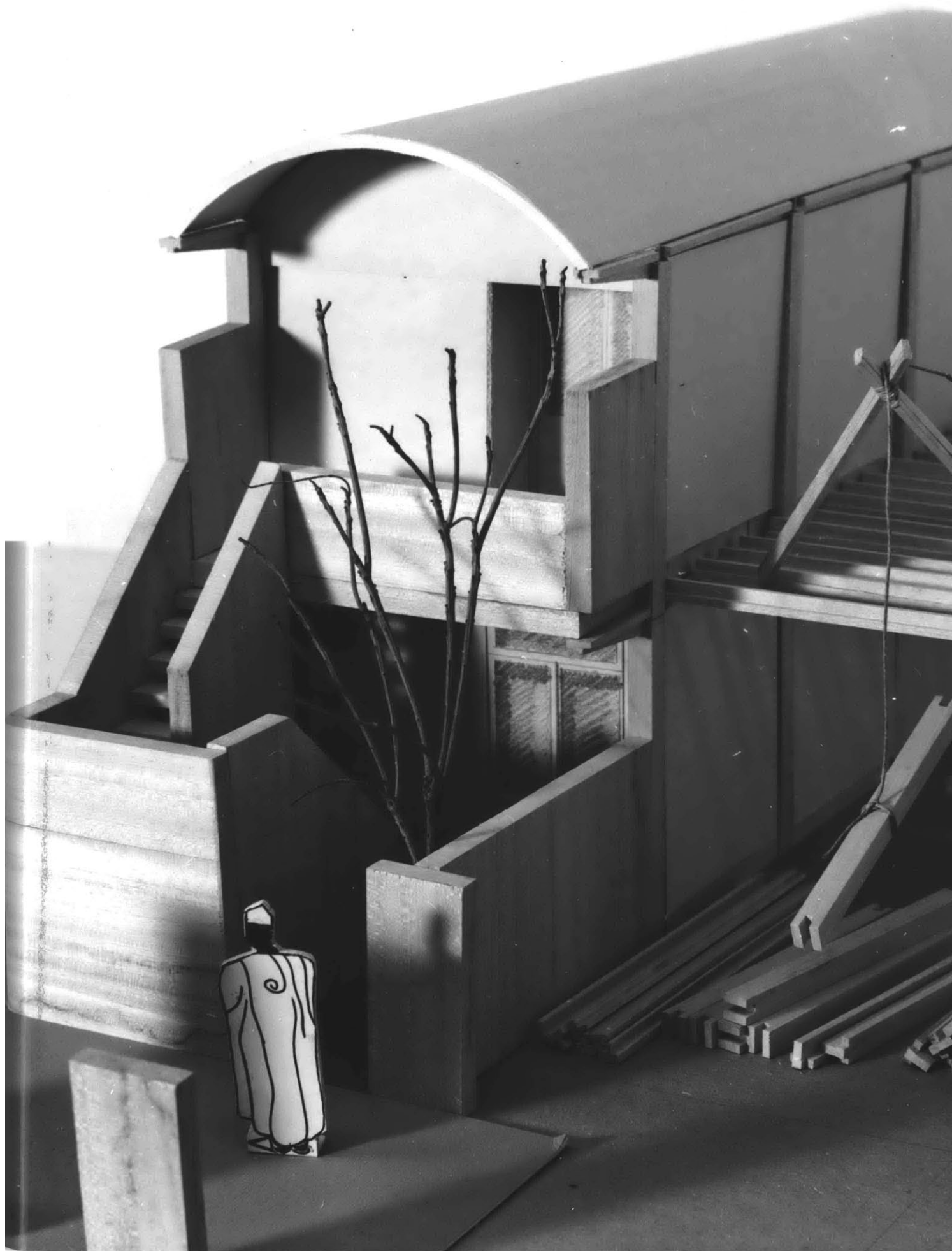
LOW COST HOUSING
IN WEST AFRICA

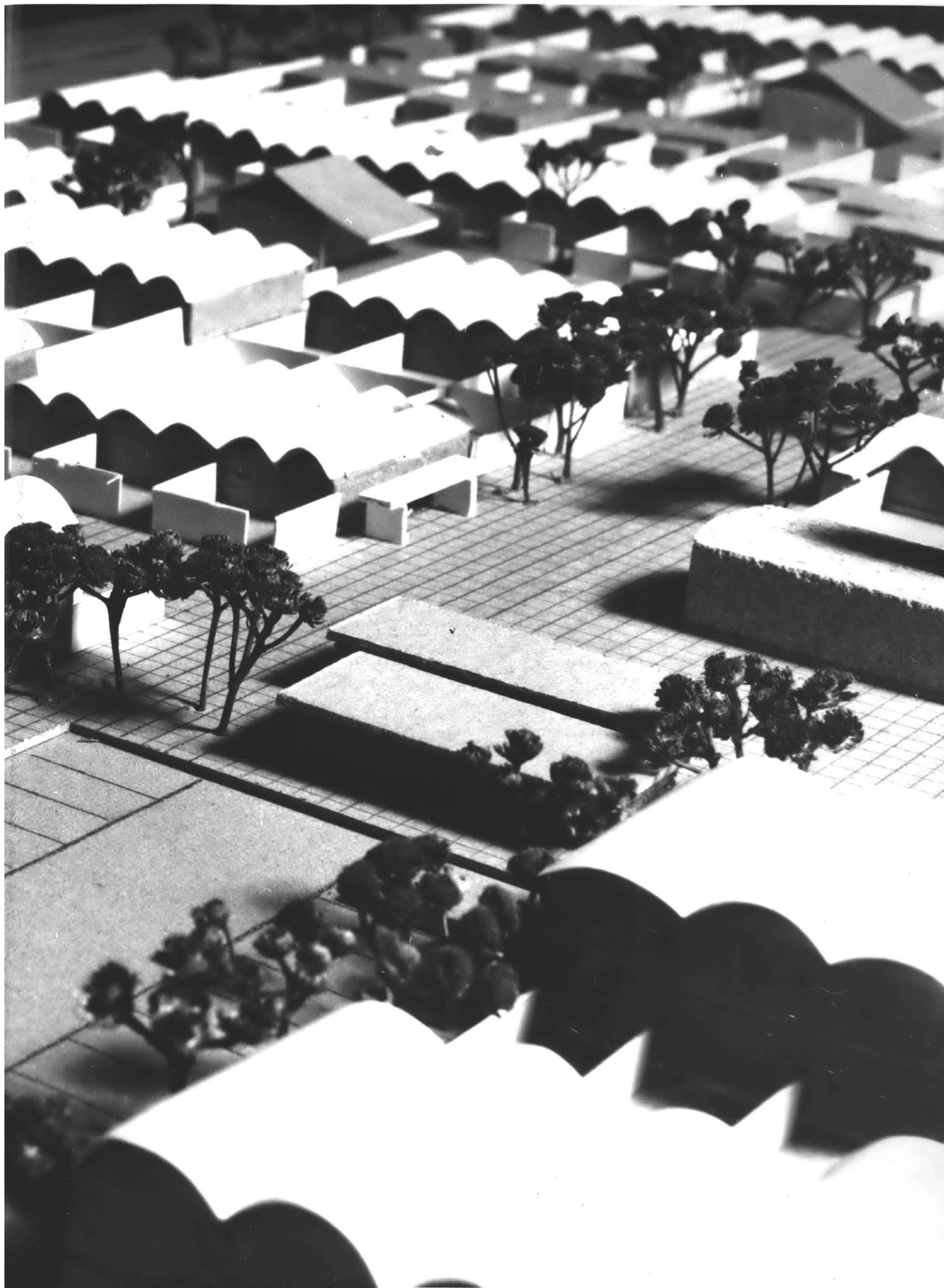
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MASTER IN ARCHITECTURE THESIS
GERARD COURTIEUX JUNE 1967

SYSTEM OF CONSTRUCTION

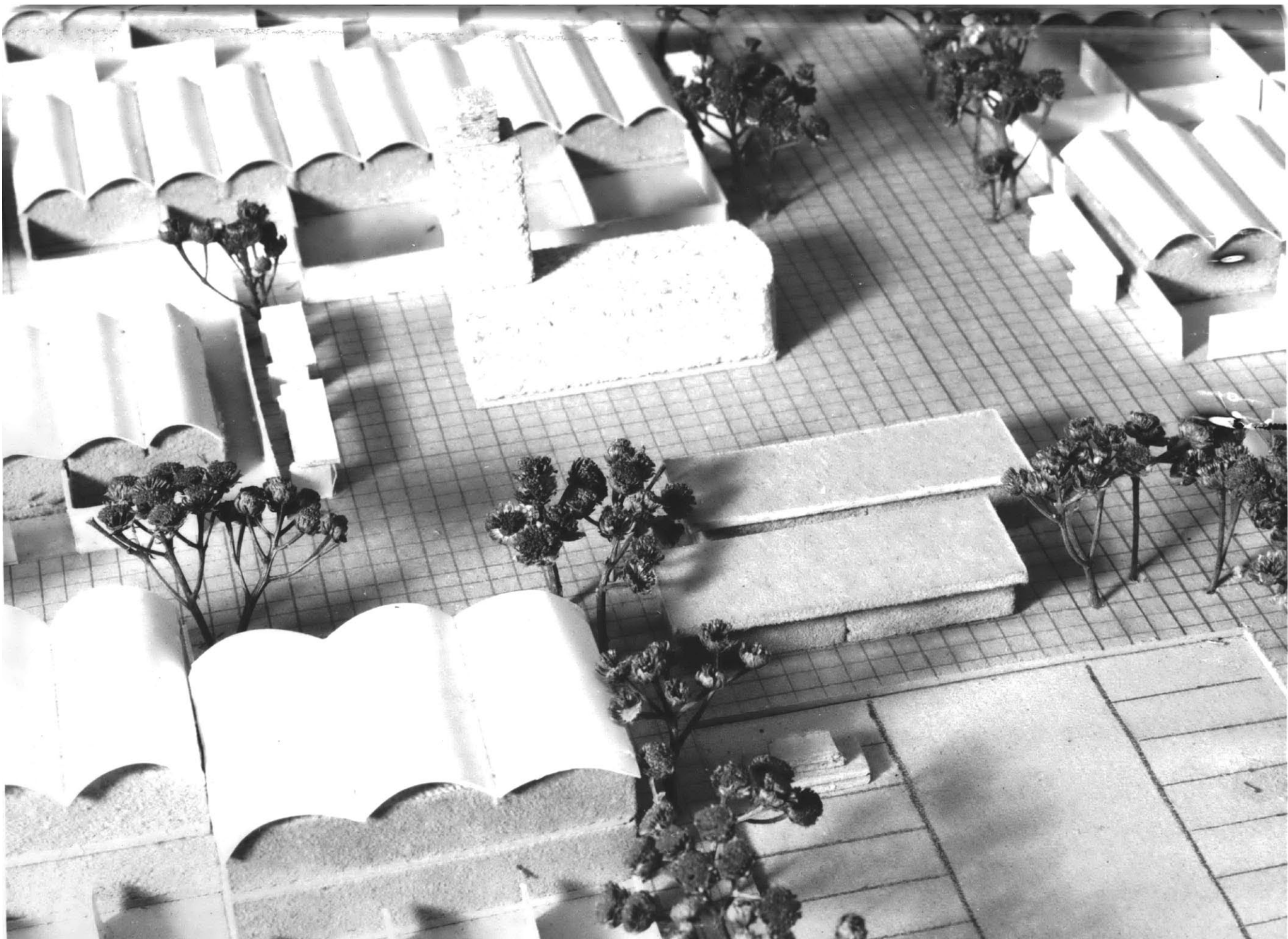












CONCLUSION

Having finished this study, we can see that despite the introduction of certain innovations in housing and urban development policy in West Africa, the housing problem has not been solved for all social levels of the population. Unless land is more inexpensively developed, 20 percent of the population of Dakar will not be aided.

These proposals, such as self help construction and the sale of urban land, will have a jarring effect on public authorities, who are too often concerned only with spectacular projects.

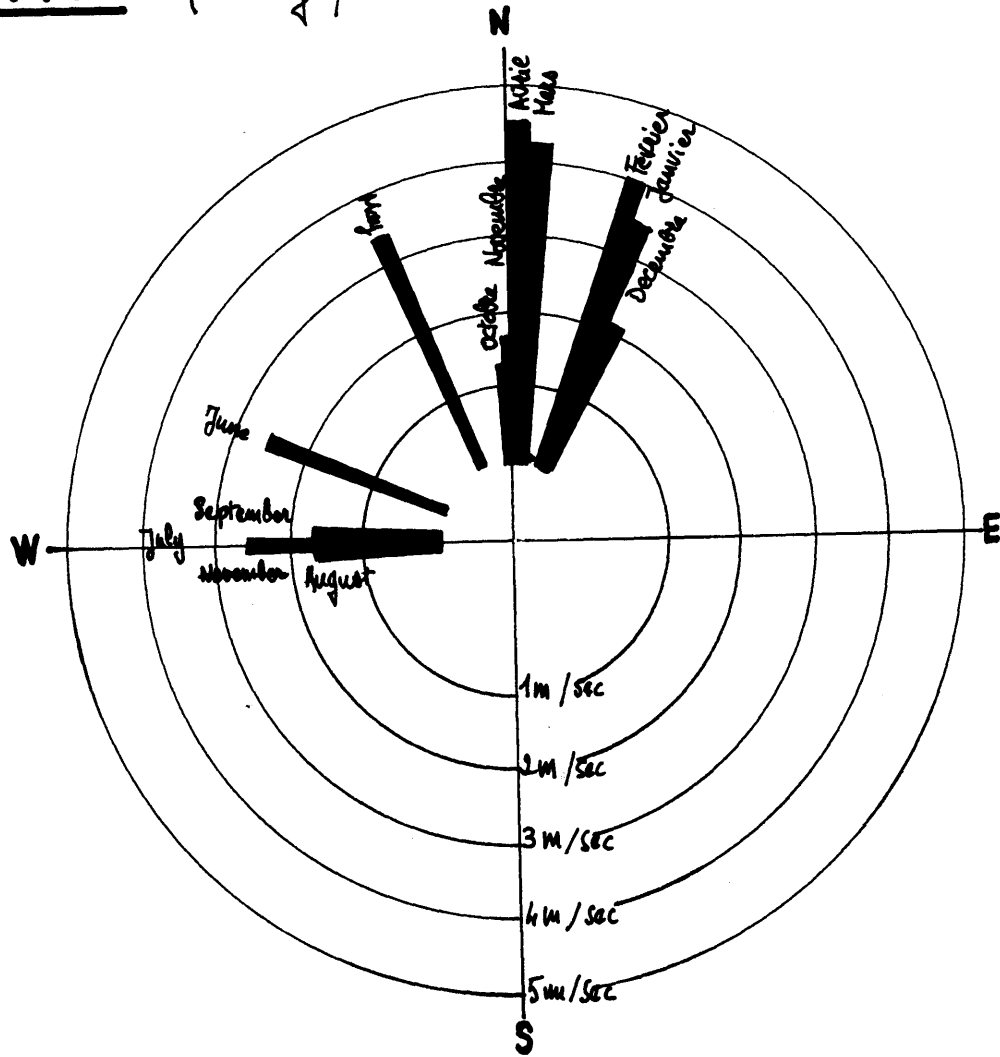
Nevertheless, much responsibility rests with this public authority. Undoubtedly, the first and most important of these responsibilities is the education of the individual citizen in regard to his housing conditions. To encourage the individual to build (for he often is nomadic-minded), to develop a sense of good workmanship, and to make him aware of his responsibilities to the community are the objectives which must be sought to augment the effect of technological solutions.

Cambridge, June 1967.

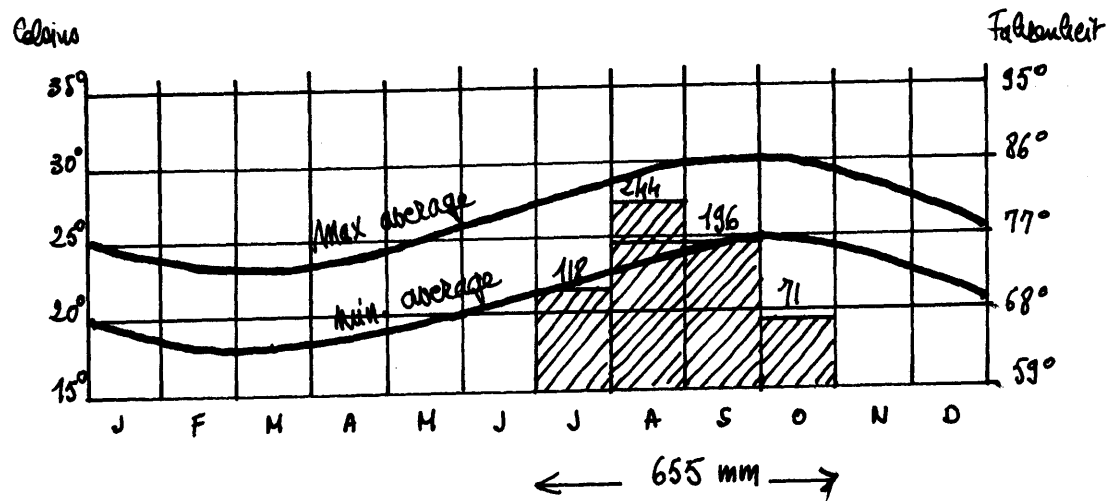
A P P E N D I X 1

CLIMATE IN DAKAR

WINDS (Average)



TEMPERATURE AND RAIN



A P P E N D I X 2

RELATIONSHIP BETWEEN INCOME, RENTING AND MORTGAGE

RELATIONSHIP BETWEEN INCOME, RENTING AND MORTGAGE
IN THE EXISTING DEVELOPMENTS

| Monthly family income dollars | Mortgage percent | Renting percent | Percentage on the total of the population |
|-------------------------------------|---------------------|---------------------|---|
| 0 - 40 | | 0,5 | 20 |
| 40 - 80 | 1,4 | 22,4 | 33 |
| 80 - 120 | 8,5 | 45,8..total 68,7 | 21 |
| 120 - 160 | 22,7 | 20,1 | 12 |
| 160 - 200 | 29,1..total 61,7 | 7,3 | 5 |
| 200 - 240 | 14,9 | 1,8 | 3 |
| 240 - 280 | 7,1 | 1 | 2 |
| 280 - | 16,3 | 1 | 4 |

Nota: At least 40 % of the population is not aided by the
existing developments.

Mortgage is possible only to 25 % of the population
with the highest incomes.

A P P E N D I X 3

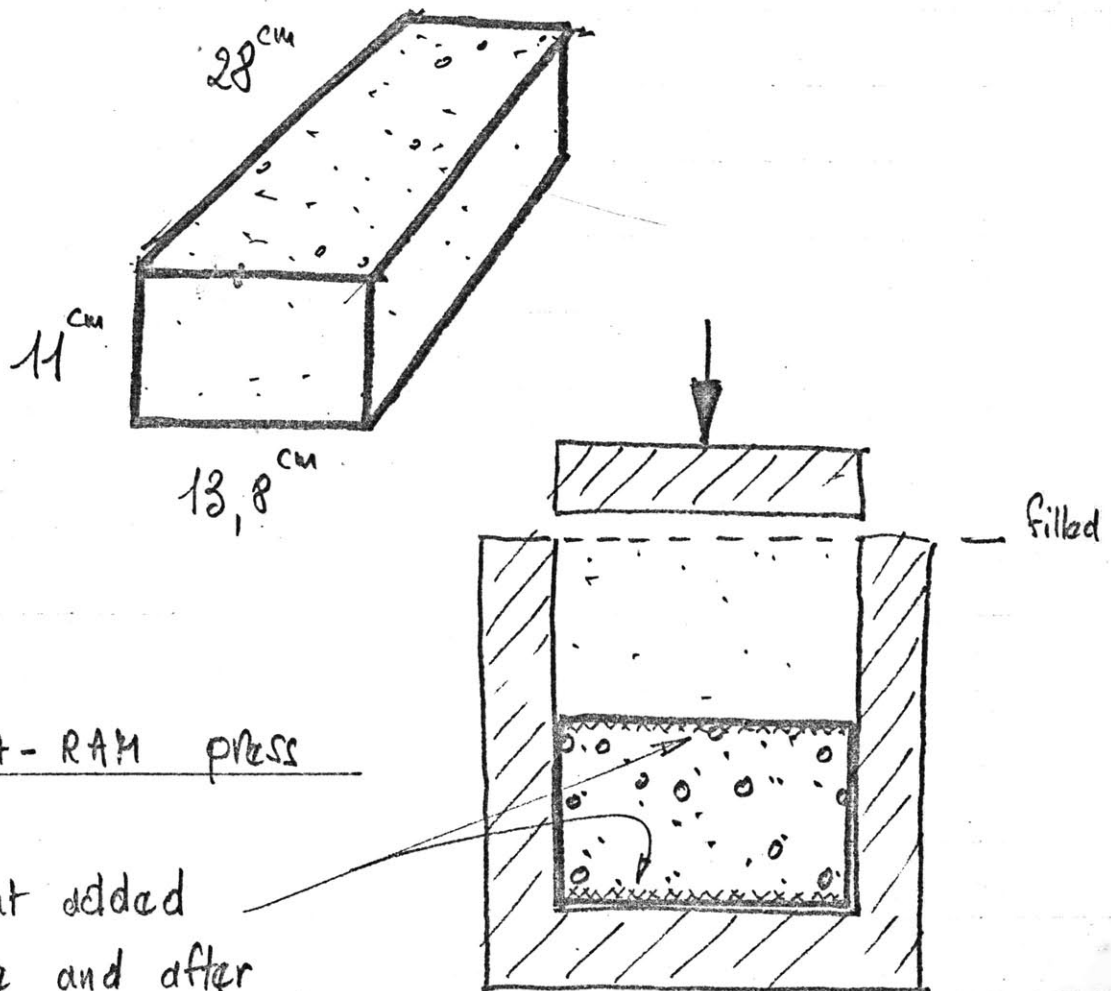
SURVEY OF EXISTING SYSTEMS AND MATERIALS

stabilized earth bricks

100 kg cement / m^3 of laterite
(red earth)

cost of one brick :
4 FCFA ~~≠~~ 2 cents U.S.

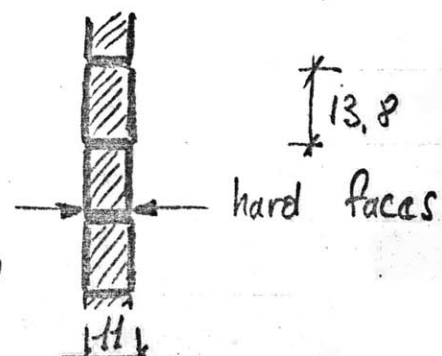
Size : 11 cm x 13,8 cm x 28 cm



CINVA-RAM press

cement added
before and after
the filling of the form
gives 2 hard faces

The bricks must be used this way

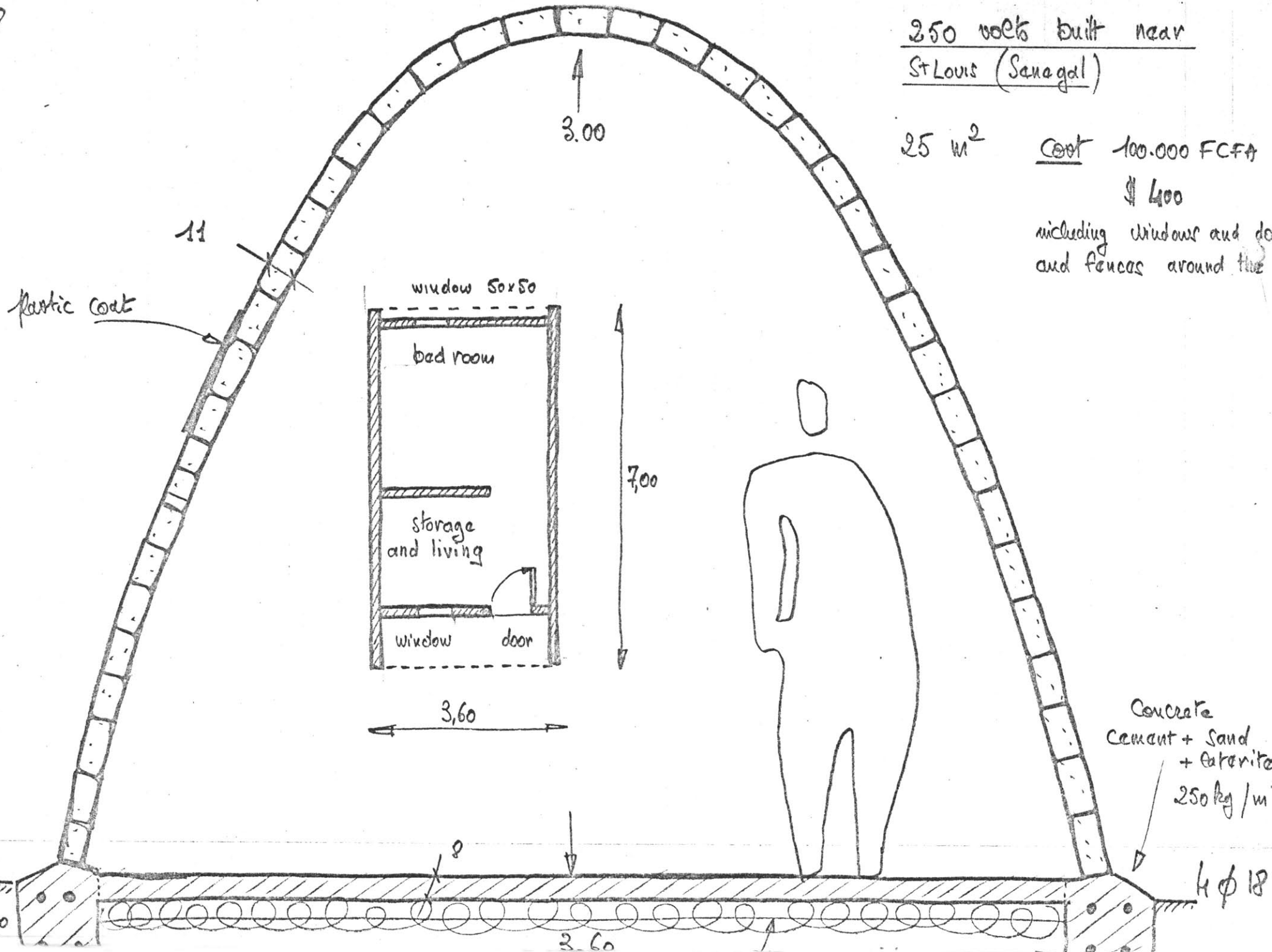


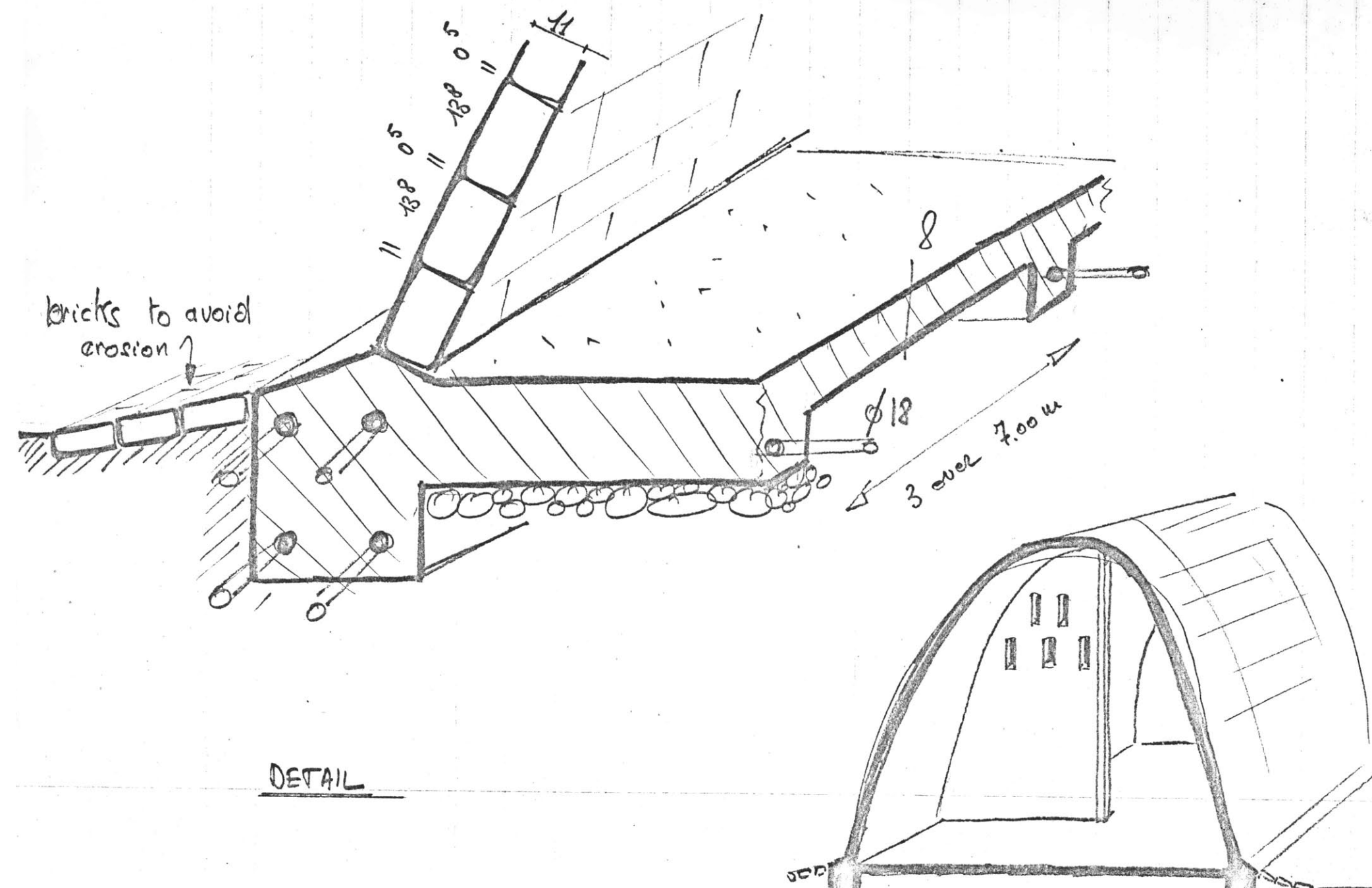
2

250 vols built near
St Louis (Senegal)

25 m² Cost 100.000 FCFA
\$ 400

including windows and doors
and fences around the

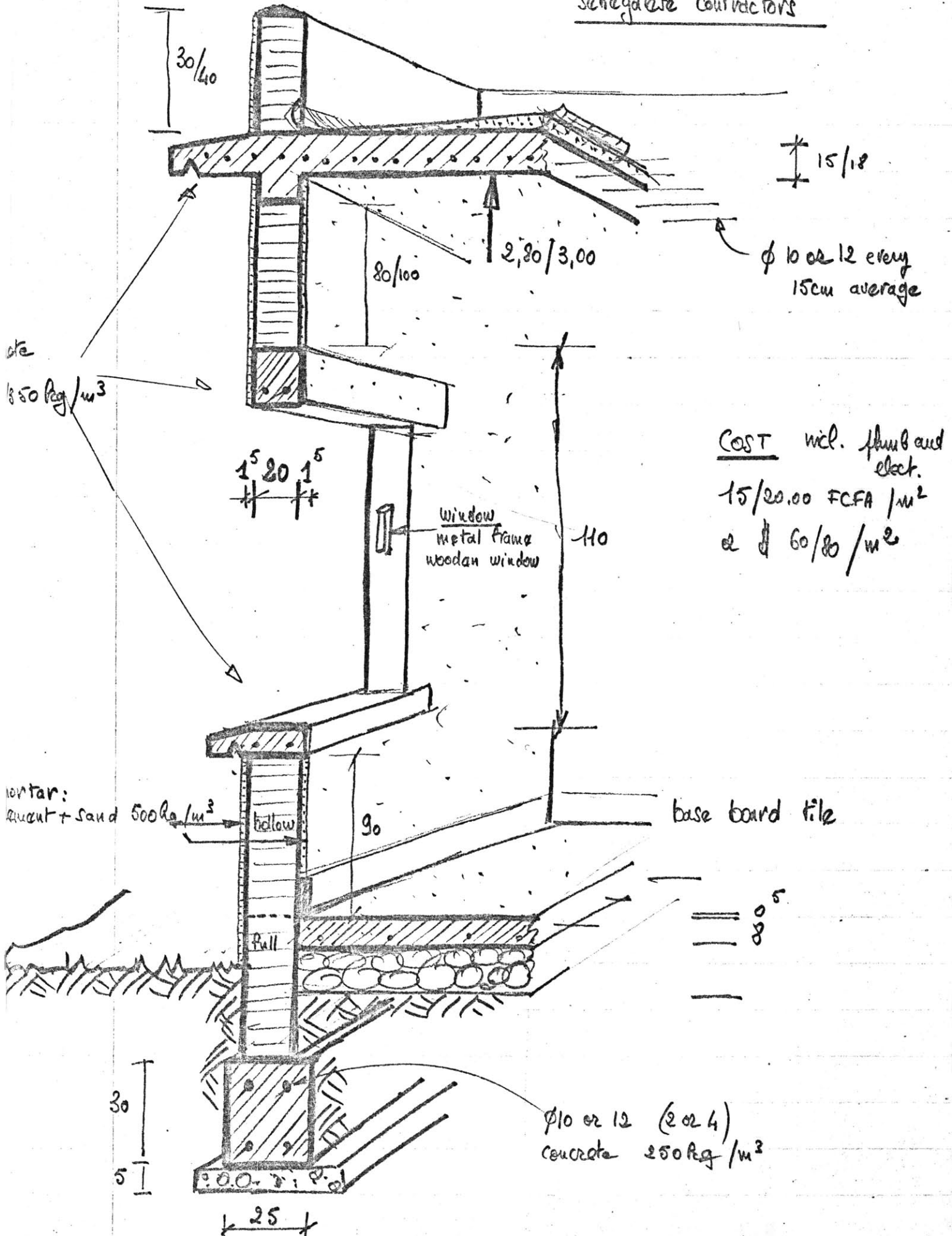


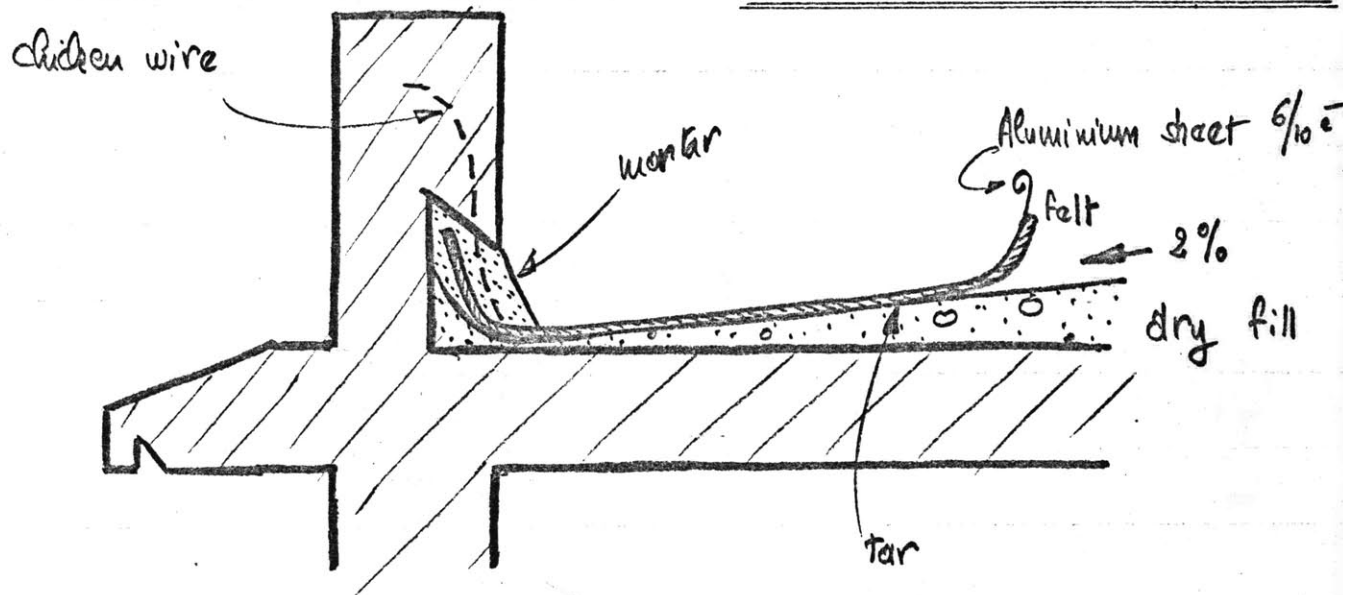


TRADITIONAL SYSTEM

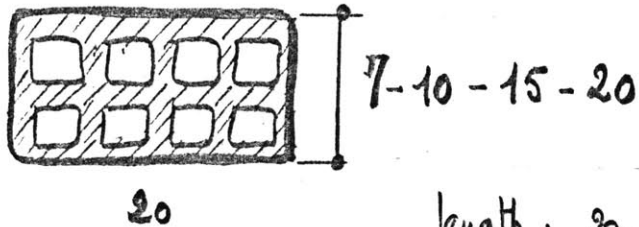
traditional - built by
Senegalese contractors

4

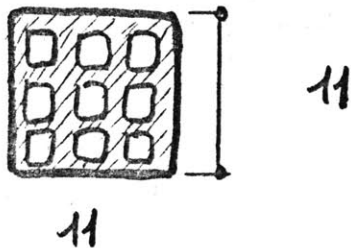


BUILT UP FELT PLY ROOFINGDETAIL

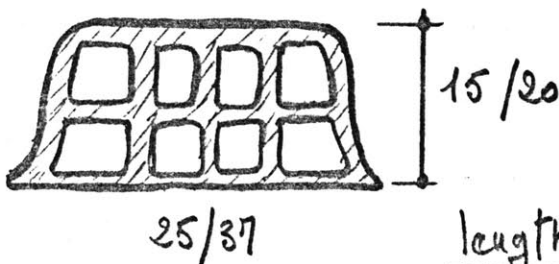
BRICKS AVAILABLE IN SENEGAL



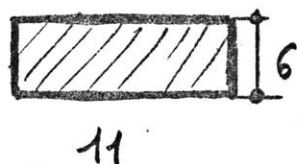
length : 30-40



length : 22



length : 33



length : 22

CONCRETE BLOCKS

7-10-15-20 x 20 x 40

WOOD

22 x 8

15 x 8

11 x 8

8 x 8

6 x 8

40, 27, 20, 18 mm.

A P P E N D I X 4

REINFORCED CONCRETE DESIGN

live loads

French regulations:

$$175 \text{ kg/m}^2$$

climate coefficient +10% total $\approx 190 \text{ kg/m}^2$

$$- \quad 2,40 \times 3,60 \times 190 = 1650 \text{ kg}$$

a) Max moment before forming top of beam:

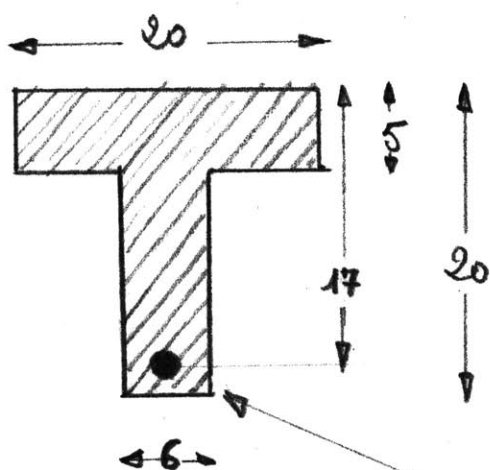
| | | |
|---------------------------|---|----------------|
| Floor | : | 2 150 kg |
| beam d. load | : | 100 kg |
| live loads $\times 1/2$: | | 800 kg |
| | | <hr/> 3 050 kg |

effective span: 2,30 m

$$\text{load per m} \quad \frac{3050}{230} = 1270 \text{ kg/ml}$$

$$\text{max moment} \quad \frac{1270 \times 5,3}{8} = \underline{840 \text{ kgm}}$$

Verification



$$\begin{aligned}\overline{\sigma}_b &= 80 \text{ kg/cm}^2 \\ \overline{\sigma}_a &= 2400 \text{ kg/cm}^2 \\ m &= 10\end{aligned}$$

$$M = 840 \text{ kg/m}$$

$$1 \phi T 20 = 3.2 \text{ cm}^2$$

$$\frac{20 \times 25}{2} - 10 \times 3.2 (17 - 5) < 0$$

$$\frac{6 y_1^2}{2} + 14 \times 5 (y_1 - 2.5) - 32 (17 - y_1) = 0$$

$$y_1 = 5.7$$

$$\frac{M}{K} = \frac{6 \times 185}{6} + (14 \times 25 \times 1.2) - (32 \times 11.3 \times 17) = 5540$$

$$K = \frac{84000}{5540} = 15$$

$$\underline{m = 15 \times 5.7 = 85 \text{ kg/cm}^2}$$

$$\underline{m'_a = 10 \times 15 \times 11.3 = 1700 \text{ kg/cm}^2}$$

Shear

$$C_1 = \frac{1525}{0,85 \times 6 \times 17} = 18 \text{ kg/cm}^2 < \frac{\sqrt{f_c}}{4}$$

b) final moment:

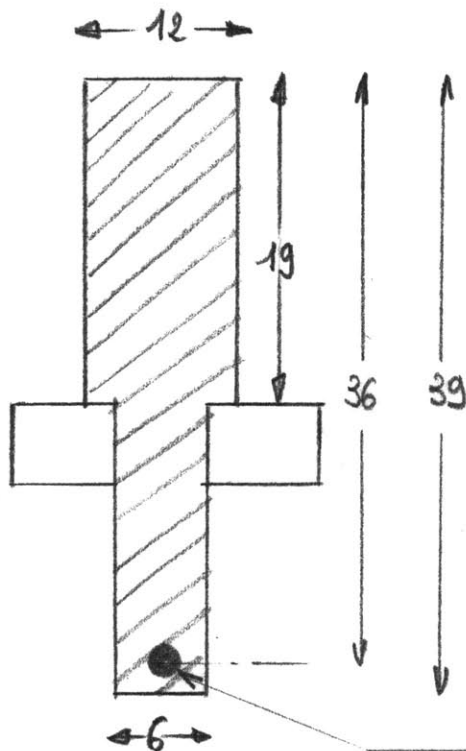
| | | |
|-------------------|---------------|-----------------------------------|
| longitudinal wall | 1150 kg | |
| transversal wall | | 1680 kg (concentrate middle span) |
| Floor | 1900 kg | |
| Beam dead load | 100 kg | |
| live loads | 1650 kg | |
| | <hr/> 4800 kg | |

$$\text{load per m} \quad \frac{4800}{2,30} = 2100 \text{ kg/ml}$$

$$\text{max moment} \quad \frac{2100 \times 5,3}{8} = 1400 \text{ kgm}$$

$$\text{moment transv. wall} \quad \frac{1680 \times 2,4}{4} = \frac{1000 \text{ kgm}}{2100 \text{ kgm}} \quad \text{total max m:}$$

Verification



$$\overline{\sigma}_b = 80 \text{ kg/cm}^2$$

$$\overline{\sigma}'_a = 2400 \text{ kg/cm}^2$$

$$m = 10$$

$$\sigma_{\text{max}} = 2400 \text{ kg/cm}^2$$

$$1\phi T 20 = 3.2 \text{ cm}^2$$

$$\frac{12 y_1^2}{2} - 32 (36 - y_1) = 0$$

$$y_1 = 11.4$$

$$\frac{M}{K} = 1440 - 6 \times 360 \times 0.6 - 32 \times 24.6 \times 36 = |28000|$$

$$K = \frac{24000}{28.000} = 8.6$$

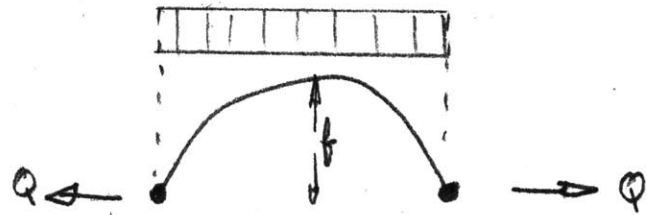
$$\underline{m_b} = 8.6 \times 11.4 = \underline{98 \text{ kg/cm}^2} \quad \text{accepted because } b > 12 \text{ cm}$$

$$\underline{m'_a} = 86 \times 25 = \underline{2150 \text{ kg/cm}^2}$$

Shear

$$c = \frac{4000}{0,85 \times 6 \times 38} = 20.6 \text{ kg/cm}^2 = \frac{\sqrt{f_c}}{4} \quad \text{OK.}$$

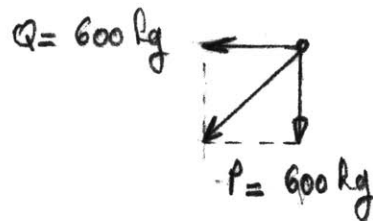
Design of the rafter



$$Q = \frac{pl^2}{8f}$$

$$Q = \frac{\frac{2,150}{3,6} \times 3,6 \times 3,6}{7,2} = 600 \text{ kg per m}$$

2 ϕ T 12 ($2 \times 1,17 \text{ cm}^2$) will be the ties for the all width.



$$R = 250 \text{ kg}$$

$$n = \frac{250}{100 \times 10} < 10 \text{ kg/cm}^2 \text{ (max for Bricks)}$$



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